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AFWAL-TR-82-1160

AD C032271

# RF CHAIN FINAL TECHNICAL REPORT(U)

NORTHROP CORPORATION
DEFENSE SYSTEMS DIVISION
600 HICKS ROAD
ROLLING MEADOWS, ILLINOIS 60008

AF WRIGHT AERONAUTICAL LABORATORIES

JANUARY 1983

TECHNICAL REPORT AFWAL-TR-82-1160

Final Report for Period October 1979 - October 1982

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| REPORT DOCUMENTATION PAGE | | READ INSTRUCTIONS BEFORE COMPLETING FORM |
|---|---|---|
| 1. REPORT NUMBER<br>AFWAL-TR-82-1160 | 2. GOVT ACCESSION NO.<br>AD-C032 271L | 3. RECIPIENT'S CATALOG NUMBER |
| 4. TITLE (and Subtitle)<br>RF CHAIN FINAL TECHNICAL REPORT | | 5. TYPE OF REPORT & PERIOD COVERED<br>Oct 79 - Oct 82 |
| | | 6. PERFORMING ORG. REPORT NUMBER<br>DSD-094-010082A |
| 7. AUTHOR(s)<br>S. Tucker<br>R. Rutter J. Dawson | | 8. CONTRACT OR GRANT NUMBER(s)<br>F33615-79-C-1821 |
| 9. PERFORMING ORGANIZATION NAME AND ADDRESS<br>Northrop Corporation, Defense Systems Division<br>600 Hicks Road<br>Rolling Meadows, Illinois | | 10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS<br>4470 |
| 11. CONTROLLING OFFICE NAME AND ADDRESS<br>Dept. of the Air Force, Air Force Systems Command, Aeronautical Systems Div/PMREC | | 12. REPORT DATE<br>January 1983 |
| | | 13. NUMBER OF PAGES<br>174 |
| 14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)<br>DCASMA Chicago<br>O'Hare International Airport<br>P. O. Box 66911<br>Chicago, IL 60666 | | 15. SECURITY CLASS. (of this report)<br>SECRET |
| | | 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE<br>31 August 1998 |

16. DISTRIBUTION STATEMENT (of this Report)

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17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Same

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

TWTs, TWTAs, EW

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(U) The RF chain program was an effort to reduce the cost of EW systems through commonality of design in the TWT amplifier chain. The purpose of this effort was to realize a standard RF chain amplifier design. A high band and low band amplifier unit was designed, constructed, and tested. The only design defference between the two units are those necessitated by their different frequency requirements.

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## PREFACE

(U) This final technical report on the Standard RF Chain program was prepared for the Avionics Laboratory, Air Force Wright Aeronautical Laboratories, Wright Patterson Air Force Base, Ohio, under Contract F33615-79-C-1821, by Northrop Corporation, Defense Systems Division, Rolling Meadows, Illinois. The Air Force program manager is R. Hieber (AFWAL/AAWW-2).

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# SECTION I

# INTRODUCTION AND SUMMARY (U)

## 1.1 (U) Brief History and Rationale

(U) The object of the Standard RF Chain Program is to reduce the total cost of Electronic Countermeasures (ECM) systems. The usual approach to designing ECM systems has been to define system performance requirements and allow specific rf chain element designs to evolve, based on these requirements and component availability. This approach has resulted in systems with similar but different designs and which use similar components that are not usable by or common to more than one system. Since the rf chain portion of these systems has been a major cost driver, commonality of components and standardization of the rf amplifying chain is an obvious way to reduce total system costs.

(U) Efforts to reduce ECM costs started with the ECM cost reduction conference sponsored by AFAL in 1975. As a result of this conference, a study was initiated to examine the feasibility of standardizing rf chains through the use of standard or common traveling wave tubes (TWTs) and other components. Study results showed a potential for achieving a common TWT/rf chain design across Air Force mission areas.

(U) As a result of the rf chain studies, AFAL briefed the Joint Director of Laboratories Council (JDLC) on the opportunities for cost reduction through rf chain standardization. The JDLC initiated a tri-service ad hoc committee, which reviewed common ECM requirements and recommended approaches toward achieving TWT and rf chain commonality.

(U) A common design would significantly reduce ECM costs, especially considering TWTs, which typically represent 20-25% of the total system costs. The use of standardized components and designs will allow larger quantity buys (with subsequent lower costs), and simplify modifications, maintenance procedures, and training.

1.2 (U) Program Objectives

(U) The following design objectives were developed for the Standard RF Chain Program in accordance with the program objectives presented in the previous paragraphs:

a. Compatibility with a wide variety of TWTs, i.e., with minimal modifications of the LRUs when changing TWTs.

b. High commonality of designs and components between the high band and low band LRUs.

c. High reliability.

d. Simplified maintenance, easily accessible test points and easily replaceable components to simplify testing, fault isolation, and repairs.

1.3 (U) Summary of Test Results

(U) The rf chain high band and low band power amplifier line replaceable units (LRUs) were developed, fabricated, and then tested using various TWTs and associated test objectives. The testing performed on each LRU is shown below:

| Low Band LRU Testing | High Band LRU Testing |
|---|---|
| RF Chain Baseline TWTs | RF Chain Baseline TWTs |
| Environmental | DBDM TWT - 2% Duty Cycle |
| Power Share Control Module | Band III Pulse TWT - 8% Duty Cycle |
| | 6 dB Dual Mode TWT |

(U) Discussion of the low band LRU testing is contained in section 3, and the high band LRU testing in section 4.

(U) High commonality was achieved between the high band and low band LRUs. They have about 70% commonality in their components and design. The only design and component differences were introduced by the different frequency range requirements of the two units.

(U) The testing provided conclusive evidence that both the low band and high band LRUs met or exceeded all specification requirements of the rf chain program. The LRUs also exhibited very high reliability throughout the testing at all the test locations.

# SECTION II

# RF CHAIN AND TEST FACILITY DESCRIPTION(U)

## 2.1 (U) RF Chain Description

2.1.1 (U) Item Definition. The Standard RF Chain Amplifier is packaged as two modules (high band and low band), each covering a different frequency range. Each module provides a combined Continuous Wave (CW) and pulse mode capability over a frequency range greater than an octave, and shares a common electrical design, form factor, and packaging concept. The modules also have high commonality (about 70%) among their components. Major components such as the high voltage modulators and power supplies are standardized to accommodate a variety of TWTs. The variable configurations thus obtained can readily be produced for a wide range of ECM applications, wherein all control functions are provided external to this rf amplifier.

(U) The baseline configuration of a standard rf amplifier module contains separate CW and pulse TWTs operating in parallel. Two flyable prototypes - a low band (E/H) version and a high band (H/J) version - have been built and demonstrated (see figure 1). The standard module is designed also to accommodate dual mode (CW/ pulse-up) and dual beam dual mode (DBDM) TWTs; these configurations have undergone critical testing.

(U) The amplifier module is packaged as an LRU and is designed for military airborne environments typical of both pod and internal installations. Cooling air can be supplied by either aircraft ECS or ram inlet. Direct cooling of the electronics is by cold plate in hermetic compartments, thereby minimizing susceptibility to dust, humidity and salt fog. The power supplies tolerate a wide AC frequency variation (350 Hz to 800 Hz) such as may be provided by a ram air turbine generator (RATG).

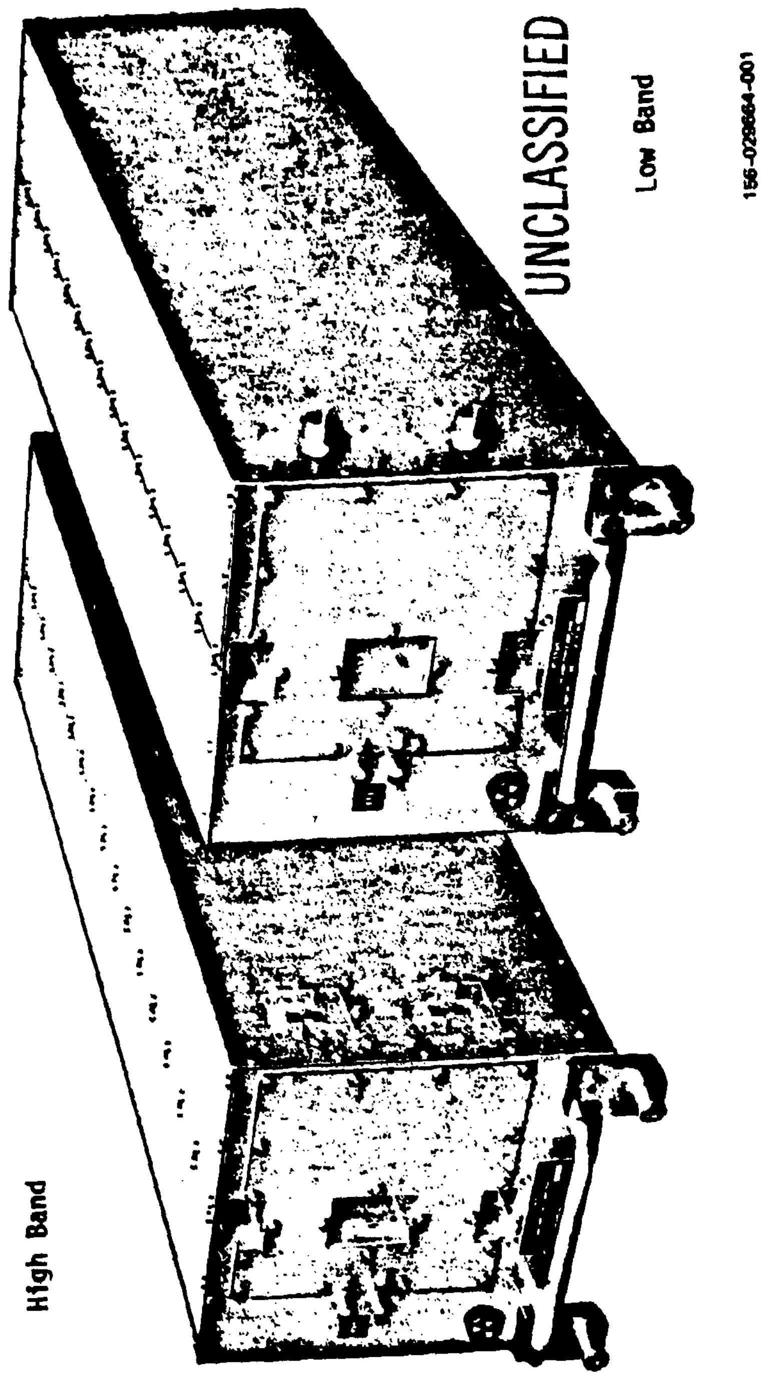


Figure 1. (U) Standard RF Amplifier, High Band and Low Band.

(U) All electronic assemblies and major components are packaged as SRUs, and are functionally partitioned in a straightforward manner, to facilitate efficient shop maintenance. Sufficient test points are accessible, via a test connector, to allow unambiguous isolation to a faulty SRU using simple and inexpensive ground support equipment.

(U) Efficient and swift flight line maintenance is facilitated by a comprehensive built-in-test (BIT) capability. The Standard RF Amplifier can safely be operated for several minutes in the aircraft without cooling air; internal temperature sensing and automatic shut-down prevent thermal damage.

2.1.2 (U) Specification Summary. The mechanical installation characteristics of the Standard RF Amplifier LRU are given in figure 2. The performance, interface and environmental characteristics are summarized in table 1.

Table 1. (U)Specification Summary, Standard RF Amplifier.

| | |
|---|---|
| FREQUENCY COVERAGE: | E/H and H/J (overlapping) |
| MODES: | CW and Pulse, interleaved |
| PULSE DUTY CYCLE: | 5% |
| GAIN (TYPICAL): | 65 dB CW, 75 dB Pulse |
| PRIME POWER: | 3-Phase, 350 Hz to 800 Hz<br>106 V ac to 122 V ac steady state<br>105 V ac to 135 V ac transient<br>1.85 KVA maximum, 1.65 KVA typical |
| WEIGHT: | 55 lbs. |
| VOLUME: | 0.68 cu. ft. |
| AIR INLET TEMPERATURE @ 25 LB/MINUTE: | $-54^{o}$C to $+60^{o}$C, continuous operation<br>$-58^{o}$C to $+80^{o}$C, 30-minute operation |
| NON-OPERATING TEMPERATURE: | $-58^{o}$C to $+110^{o}$C |

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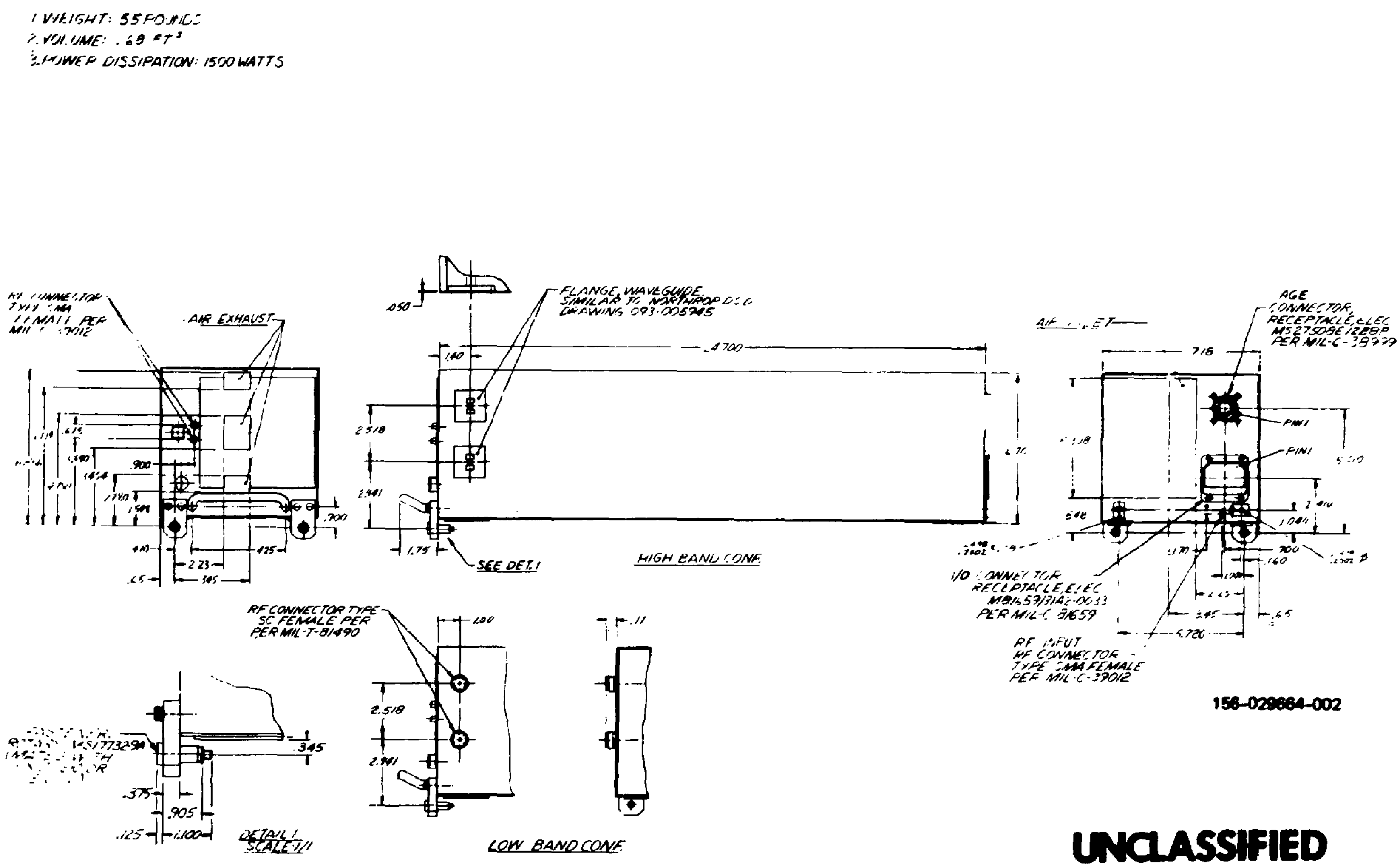


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Figure 2. (U) Installation Drawing, High Band and Low Band Standard RF Amplifier.



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2.1.3 (U) Amplifier Interface. The functional organization of the baseline amplifier configuration, low band or high band, is illustrated in figure 3. Its operation is totally controlled by an external interfacing sybsystem, such as a receiver/processor or a techniques generator.

(U) Interface between the amplifier and the controlling subsystem consists of a 6-bit data bus, a number of discrete command inputs and status outputs, and the RF input.

(U) The data bus provides two-way communication between subsystems. Data transmitted by the controlling subsystem includes mode commands (standby, transmit, etc.), measurement commands (for rf levels, etc.) and status queries. The amplifier responds with fault status data and encoded measurement values. Associated with the data bus is a separate 2-bit address code input, which allows up to four amplifiers to be controlled by the same data bus.

(U) Chief among the discrete inputs are the CW and Pulse mode commands. These inputs provide real time grid control of the TWTs via their respective modulators. Another real time input signal synchronizes the measurement of rf input power, rf output power and output pulse width, as specified by a data bus command.

(U) The discrete outputs report certain fault conditions requiring the immediate attention of the controlling subsystem. Internal faults reported by these outputs include modulator, power supply, and temperature faults. External faults reported include excessive reflected output rf power and improper pulse mode command timing format.

2.1.4 (U) Amplifier Operation. Internally, the amplifier is controlled by an I/O circuit contained in the I/O and BIT module (see figure 3). The I/O circuit decodes the data bus words and routes commands to their destinations. It also collects and encodes all status and measurement data, and routes them to the controlling subsystem.

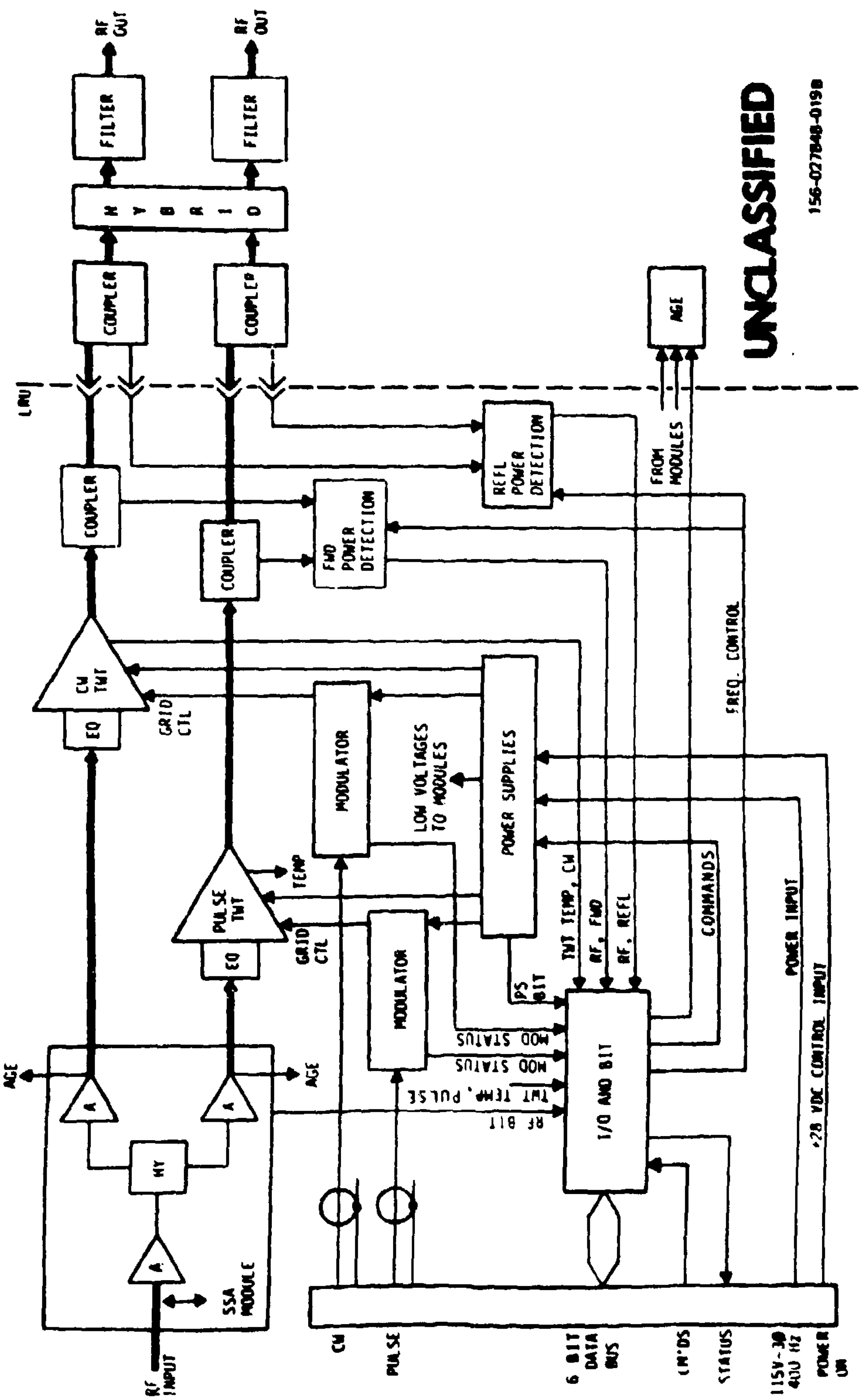


Figure 3. (U) Block Diagram, High Band or Low Band Standard RF Amplifier.

(U) The rf signal path through the amplifier begins in the solid state amplifier (SSA) module, where the rf input signal is amplified and split. The SSA module also contains an rf detection circuit; its video output is routed to a BIT circuit in the I/O and BIT module where, upon command, the amplitude is sensed.

(U) The two rf outputs from the SSA module are routed to the CW and pulse TWTs. The control grid of each TWT allows its beam current to be turned on and off rapidly by the associated modulator, in response to the input mode command. Typical propagation time for either CW or pulse mode, i.e., from input command transition to output rf signal transition, is 30 nanoseconds.

(U) Couplers at the TWT outputs provide proportional samples of rf output power to associated detection circuits, whose video outputs are routed to the BIT circuit and encoded upon command.

(U) Also shown in figure 3, but external to the amplifier LRU, is a microwave network consisting of two directional couplers, a hybrid, and two filters. The external couplers provide proportional samples of reflected RF power back into associated detection and threshold circuits within the LRU. These circuits provide real time warning of excessive voltage standing wave ratio (VSWR), for the purpose of protective shut-down and fault status reporting. Protective shut-down of the TWT is automatically performed via its grid modulator. The reflected power trip thresholds are factory adjustable for a wide range of installations.

2.1.5 (U) <u>Amplifier BIT</u>. (U) Self-test BIT circuits are contained in the modulators and power supplies, which continuously monitor for and report on faulty voltage and current conditions. Additionally, the pulse modulator protects the pulse TWT from an improper pulse command timing format, by autonomously limiting pulse repetition frequency, duty cycle and duration of a single pulse on-time. This function, when invoked, is reported as a pulse command fault.

(U) The high voltage power supply additionally monitors TWT conditions, and shuts itself down in the event of an arc-over or other faults.

(U) The temperature of each TWT is continuously monitored by the I/O circuit, which will turn off the high voltage power supply (HVPS) in the event of overtemperature. The temperatures, upon command, are also encoded and transmitted to the controlling subsystem via the data bus.

## 2.2 (U) Test Facility

(U) The RF Chain Power Amplifier test facility (figure 4) features several automated test sequences, yet is flexible enough to allow manual spot checking. The equipment may be divided into three categories: the system computer, an automated test set-up, and manual mode equipment.

(U) The HP9845 computer controls the automated portion of the facility via the IEEE Std. 488 bus. In addition, the computer drives a graphics display, plotter, printer, and data storage capability. The system software is designed to execute test sequences, create calibration data, and continuously monitor all automated equipment. The automated equipment interconnections are not changed radically between tests. In general, the automated equipment is responsible for providing various stimuli to the Power Amplifier, monitoring the status of the Power Amplifier, and making power measurements.

(U) The manual equipment items are required only for specific tests. Most manual equipment is used for monitoring the output or response characteristics of the Power Amplifier.

2.2.1 (U) <u>Special Test Equipment</u>. The Special Test Equipment (STE) for the rf chain amplifier is shown in figure 5. The two major components for the STE are a microprocessor based control console and a cooling cart.

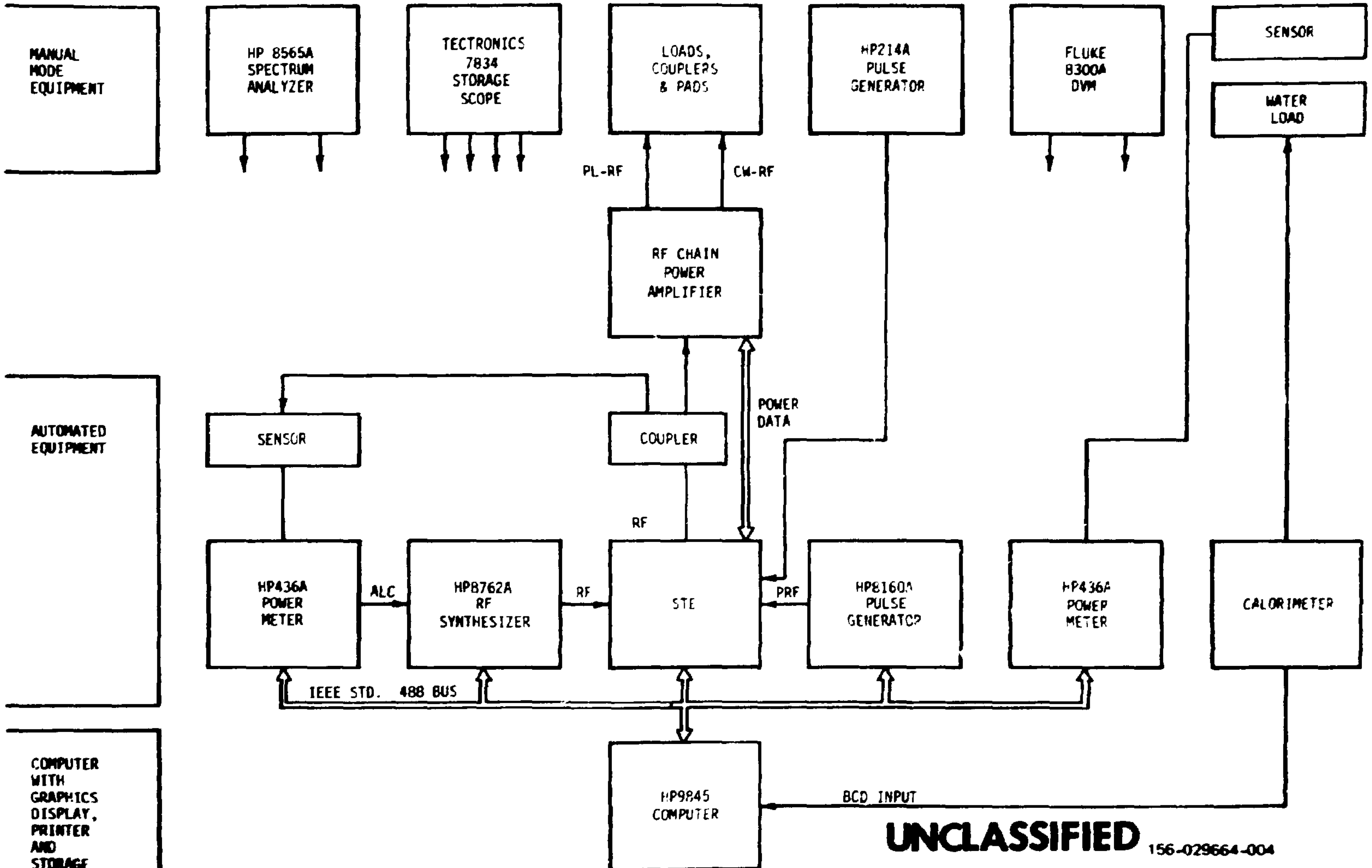


Figure 4. (U) RF Chain Power Amplifier Test Facility Block Diagram.

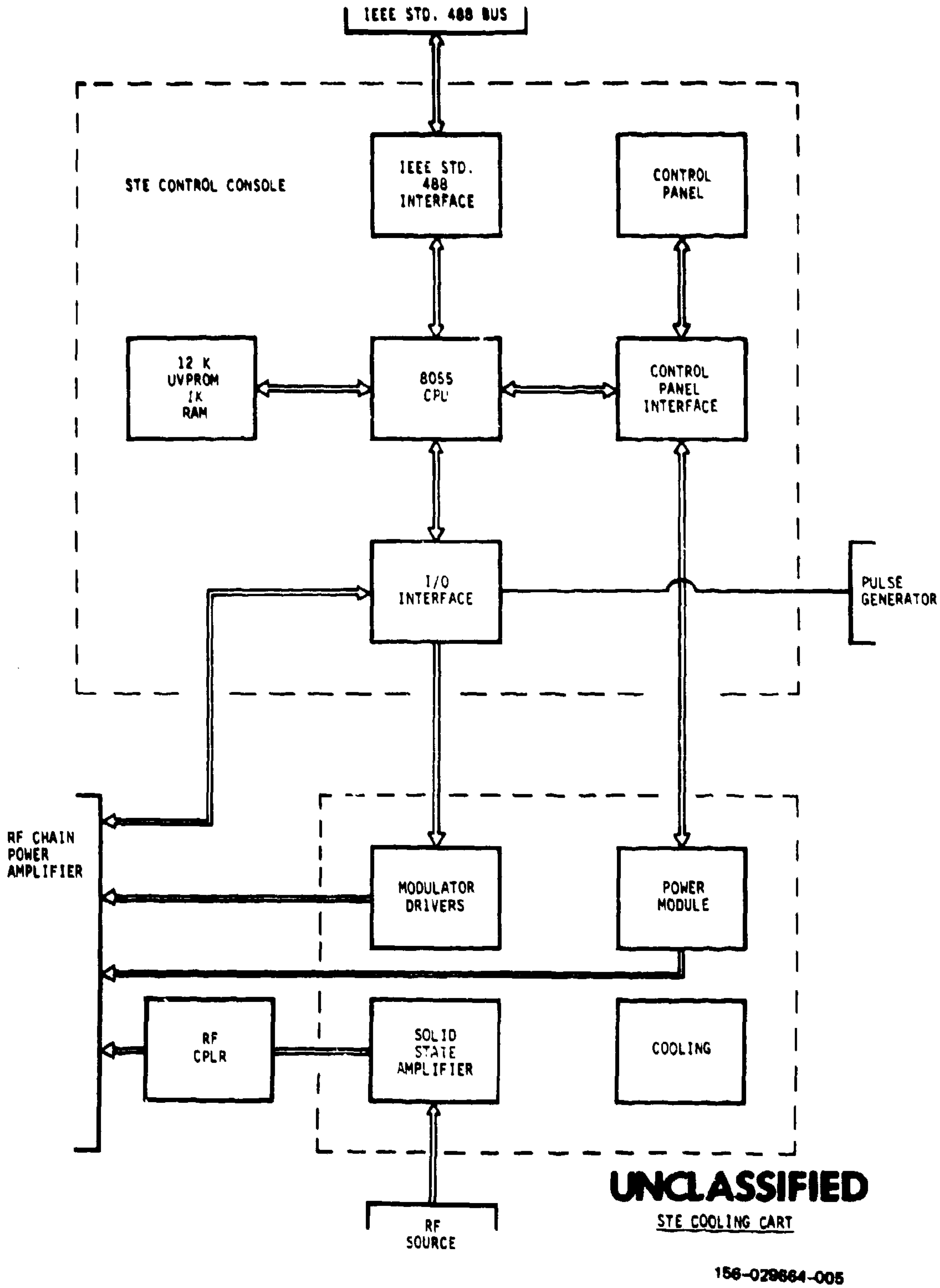


Figure 5. (U) STE Block Diagram.

(U) The main functions of the cart are to supply cooling and support for the Power Amplifier and to provide power for both the STE and Power Amplifier. In addition, the cart houses the SSA and the modulator drive circuitry.

(U) The control console features the 8085 Microprocessor, a 12K program contained in erasable PROMs and 1K of RAM. Programmable interfaces are provided for communications with the Power Amplifier, the IEEE Std. 488 bus, and a manual control panel.

(U) The STE may be operated via the IEEE bus or manually.

2.2.2 (S) Driver Amplifier Characteristics. Figure 6 is a plot of the Avantek Cascaded Amplifier gain and output power characteristics. Measurements were made over a frequency range of 8 GHz to 18 GHz for both small signal gain (SSG) and 1dB compression power output characteristics. The small signal gain approximated 35 dB $\pm$ 1.5 dB at a power output of +8.5 dBm. A minimum of +19.5 dBm output across the band at the 1 dB compression point is provided by the amplifier.

(S) Figure 7 is a plot of the harmonic power (in dBc) at 8 GHz for the above amplifier. This amplifier was operated at an output of between +18 dBm and +21 dBm which resulted in harmonics of -23 dBc maximum.

2.3 (U) Test Programs

(U) The HP9845B computer was programmed to exercise the amplifier in accordance with the testing procedures. It accomplished this by controlling the STE and other test equipment (see figure 4) and processing data through the use of the IEEE Std. 488 interface bus. The HP9845B was chosen because of its versatility and suitability to this application.

2.4 (U) RF Chain Configuration Variations

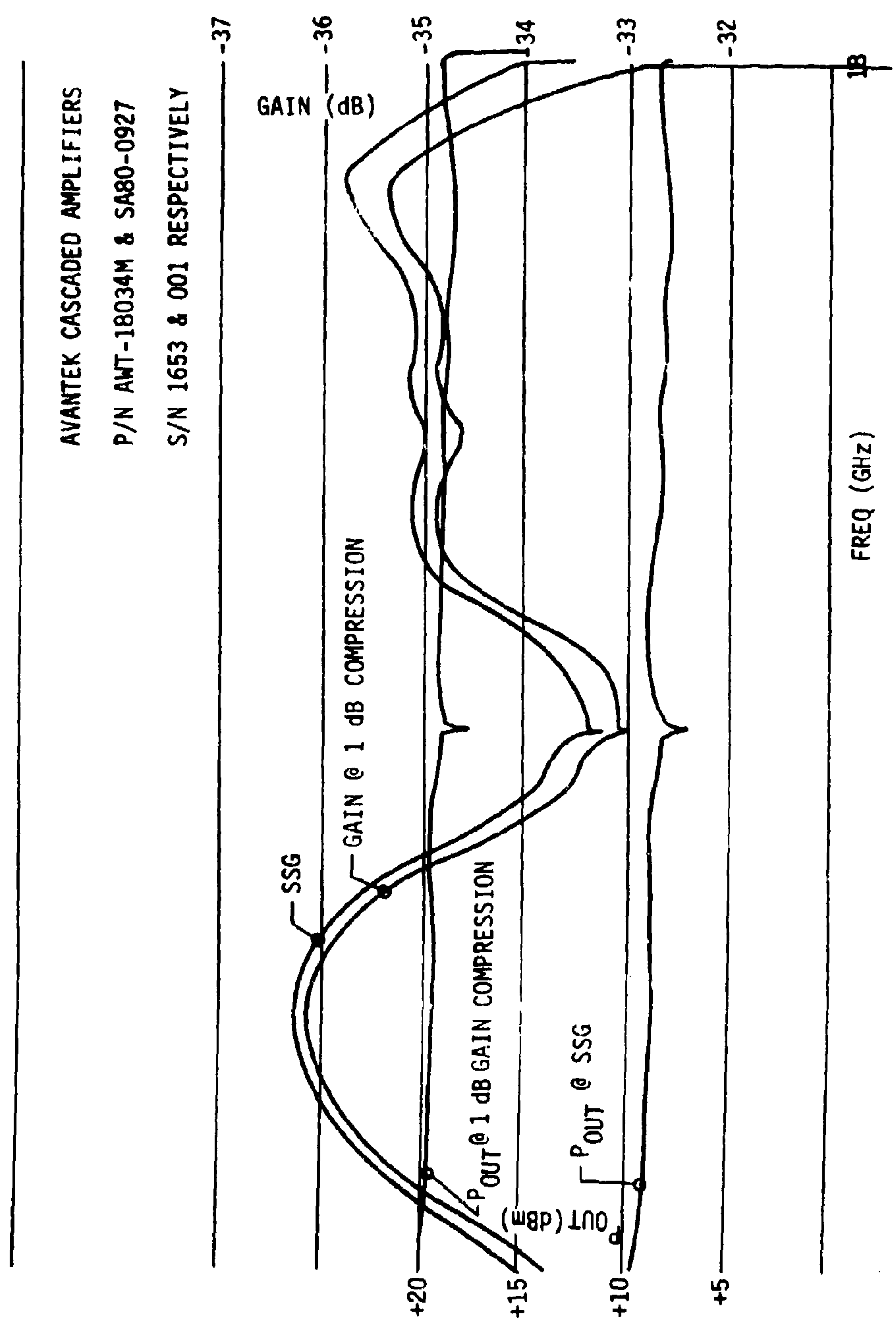


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Figure 6. (U) Gain and Power Output Versus Frequency-Cascaded Test Amplifier.

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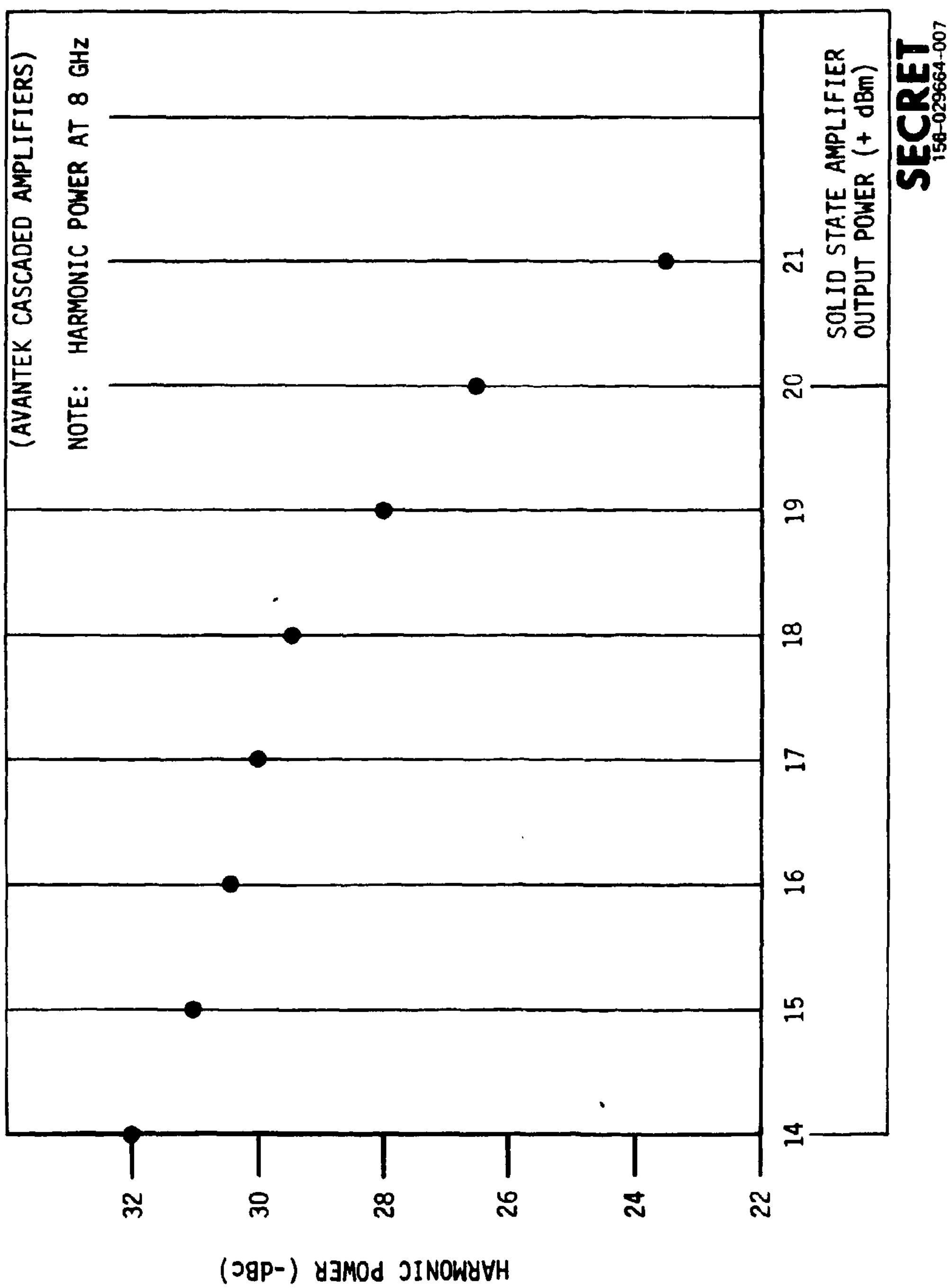



Figure 7. (U) Harmonic Power Output-Cascaded Test Amplifier.

(U) One design goal of the RF Chain Program was high compatibility of the RF Chain Amplifier with various types of TWTs. The high band LRU has been tested with four different TWTs - the baseline TWTs, the NETS/Raytheon DBDM TWT, the Hughes 8% pulse tube, and the T-MEC 6 dB pulse-up tube.

(U) The only modifications to the rf chain for changing these tubes are replacing the high voltage power supply (HVPS), and replacing the modulator for the 6 dB pulse-up tube. This is a matter of simply removing screws, replacing the supply and/or modulator, replacing the screws, and adjusting the power supply voltage levels before operation.

(U) The power supplies all fit the rf chain form factor, with the exception of the 6 dB pulse-up tubes HVPs and modulator, which are encased in FC-48 oil. Since the 6 dB pulse-up TWT is not intended for use in the rf chain, the HVPS and modulator were built for ease of modification rather than form factor.

## 2.5 (U) RF Chain Modulator

(U) At the outset of the development program, the decision was made to modify the ALQ-135 universal modulator design for application to the RF Chain Power Amplifier. This design provided the capability to control both gridded and nongridded (mod-anode) TWTs and therefore allowed the TWT manufacturers maximum flexibility in meeting the rf chain tube performance requirements. This design utilized all solid state devices, except for two triode tubes which are required to provide the 1300 volts needed to switch mod-anode from on to off and visa-versa. This modulator was prototyped for the rf chain testing.

2.5.1 (U) <u>RF Chain Modulator General Description</u>. The rf chain modulator incorporates high voltage, high current MOS power FETs as switching elements (see figure 8). Each switch section (4 sections used) is comprised of a 450 volt FET, a floating power supply, and associated circuitry. The two ON switches are virtually identical to the two OFF switches except they also have the ability to provide TWT grid current

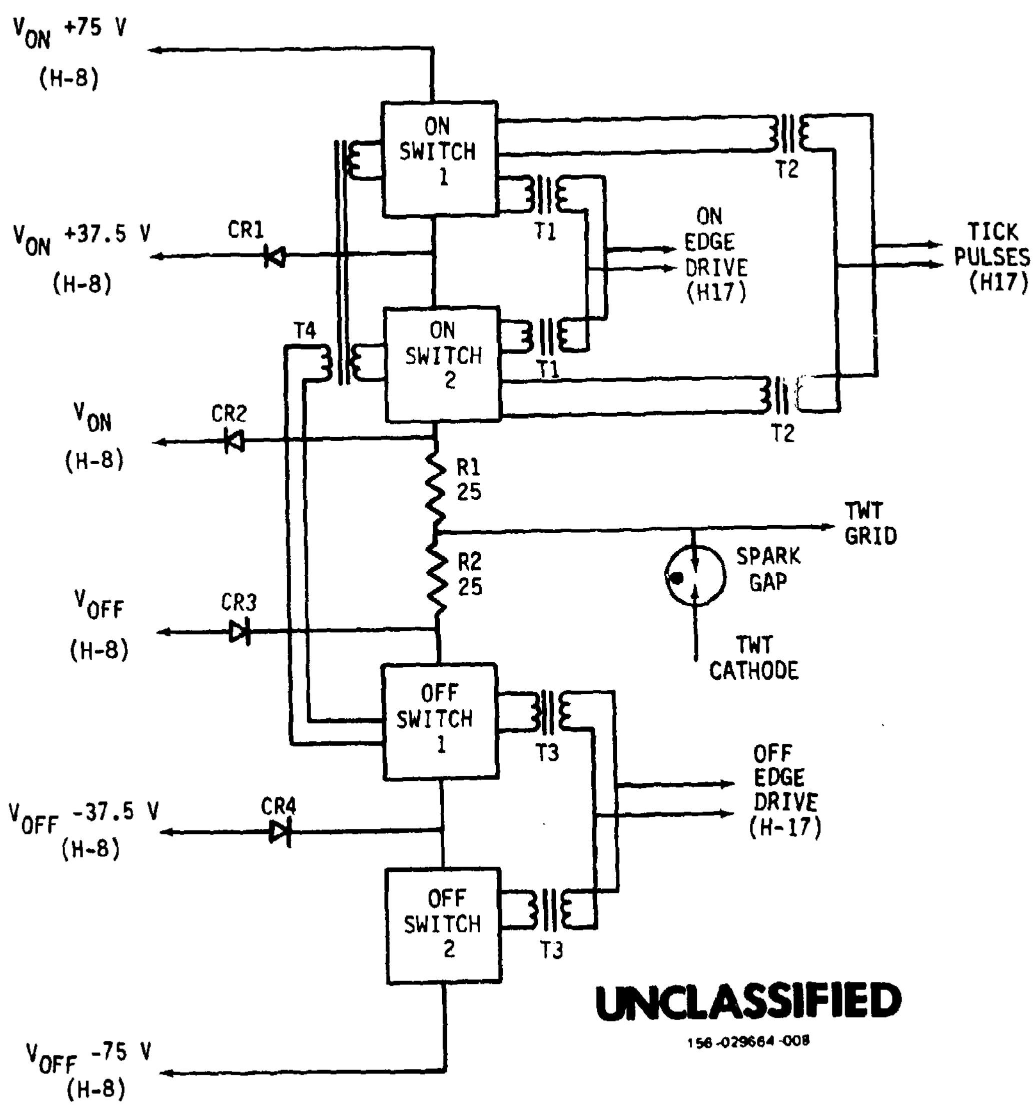



Figure 8. (U) RF Chain Modulator Block Diagram.

in excess of 200 mA if necessary. The grid is held in the off state by a large value resistor to $V_{OFF}$. Switch edge drive and tick (high frequency refresh) pulses are transformer coupled from ground level to the high voltage TWT cathode potential. The design permits usage of the H-17 driver hybrids in the modulator. The $V_{ON}$ and $V_{OFF}$ power supply also employs a common hybrid (H-8). It was modified to accommodate the lower potentials needed for the shadow grid TWT.

2.5.2 (U) Block Diagram Description. As seen in the block diagram (figure 8), the four switches are in series. The TWT grid is tied to a point between the ON and OFF switches. A spark gap between the TWT grid and cathode protects the modulator in the event of an arc from grid to ground.

(U) ON edge drive pulses are transformer coupled from H-17 to the ON switches through T1 while OFF commands are coupled through T3. When in the ON state, ON switch sustaining pulses (tick pulses) are fed through T2. Edge drive pulses develop extremely fast high current conduction of the switches to enable switching 500 volts in less than 30 nanoseconds, while the tick pulses sustain the conduction of the ON switches at the 200 mA level or whatever TWT grid current may be required. When a turn off command is sent to the OFF switches, a signal is generated by OFF switch 1 which completely shuts off the two ON switches through T4. As mentioned before, the OFF switches require no tick pulses. This local coupling negates the need of another low to high voltage transformer.

(U) Diodes CR1 and CR2 prevent the ON switches from going into "saturation" when the ON switches are energized. CR2 clamps the TWT grid to the $V_{ON}$ potential. Thus, CR1 and CR2 keep about 35 volts across each switch during their conduction period. The drain to source capacity of FETs has the property of being inversely proportional to the voltage across the FET. By minimizing the capacity of the FETs in the ON mode, switching in the opposite direction is simpler, faster, and power saving. Diodes CR3 and CR4 serve the same function in the OFF switches.

# SECTION III

# LOW BAND LRU TESTING(U)

(U) The following tests were performed on the Low Band Power Amplifier:

a. Baseline Testing
b. Environmental Testing
c. Testing with the Power Share Control Module.

The purpose and requirements of each test are detailed in the appropriate section below.

## 3.1 (U) Baseline Testing

(U) The rf chain baseline testing was conducted using the baseline T-MEC TWTs. This was done to keep the program within cost and schedule, since preliminary analysis showed that the rf chain requirements could be fulfilled by the baseline tubes. This analysis turned out to be incorrect. The baseline TWTs could not be made to meet the rf chain requirements. However, the response of the rf chain when using these tubes yields baseline data about its overall performance. Since the rf chain in most cases comes close to fulfilling the rf chain requirements with the baseline tubes, it may be inferred that the rf chain would meet or exceed these requirements with the appropriate TWTs.

3.1.1 (U) TWT Description. The following paragraphs list some of the specifications of the TWTs used in the rf chain low band LRU testing. The specification and drawing for the pulse TWT are in Northrop DSD documents 093-005931 and 090-001860, respectively; and for the CW TWT, document numbers 093-005930 and 090-001859, respectively. These are some of the relevant specifications:

(S) Frequency Range: The following frequency ranges apply to both the pulse and the CW TWT:

2.6 GHz to 7.5 GHz
2.0 GHz to 8 GHz (design goal)

(S) Rated Fundamental Power Output:

| Frequency | Power Output: CW TWT | Power Output: Pulse TWT |
|---|---|---|
| 2.0 GHz to 2.6 GHz (goal) | +51.8 dBm | +61.0 dBm |
| 2.6 GHz to 7.5 GHz | +54.8 dBm | +62.5 dBm |
| 7.5 GHz to 8.0 GHz (goal) | +53.8 dBm | +61.8 dBm |

(C) Maximum total power output shall not exceed +57.0 dBm (CW) or +66.0 dBm (pulse) regardless of drive level.

(C) Duty Cycle and Pulse Width: The pulse tube may be operated at continuous duty cycles up to 100% and at various pulse widths from CW to a minimum of 100 ns, including multiple combinations thereof.

(C) Small Signal Gain: Small signal gain for the CW TWT is 36 dB minimum, 39 dB nominal, and 46 dB maximum. Small signal gain for the pulse TWT is 46 dB minimum, 49 dB nominal, and 56 dB maximum.

(C) Noise Output: With the input port terminated in 50 ohms and the output port loaded with an attenuator, the CW TWT spurious noise output is below -10 dBm/ MHz, and the pulse TWT total integrated noise and spurious output power is below +30 dBm.

(S) At normal driver levels, the total harmonic power for each TWT is at least 3 dB below fundamental power output (-10 dBc goal). At frequencies higher than 4.5 GHz, the second harmonic is at least -15 dBc.

(C) Propagation Delay. The propagation delay for each tube does not exceed 10 ns.

3.1.2 (U) List of Tests. The baseline electrical performance tests conducted on the low band LRU are listed on the following page:

a. Power Output vs. Frequency
b. Small Signal Gain
c. Harmonic Power
d. Spurious Outputs and Noise Power
e. TWT Transfer Characteristics
f. Mismatched Loads
g. Propagation Delay
h. Mode Switching Time
i. Primary Power
j. Response to Commands
k. Duty Cycle Limiting
l. BIT/ATE Output

## 3.2 (U) Detailed Test Data - Baseline Testing

(U) The detailed test data for each test provided in this section is preceded by introductory paragraphs indicating the purpose, requirements, variations in test procedures (if any) a summary of the test results, and a block diagram of the test setup.

### 3.2.1 (U) Power Output vs. Frequency

a. (U) Purpose. The purpose of this test is to demonstrate the power output of the RF Chain Low Band Amplifier across the frequency band at nominal rf input drive levels. See figure 9 for the test setup.

b. (U) Results. Tests were run on the CW and pulse tubes for total and fundamental power output vs. frequency, and reduced drive level power output vs. frequency. The results of these tests are shown in figures 10 through 15. The lower reference line on these graphs represents the specification to which the TWTs were built. The other reference line represents the rf chain specifications.

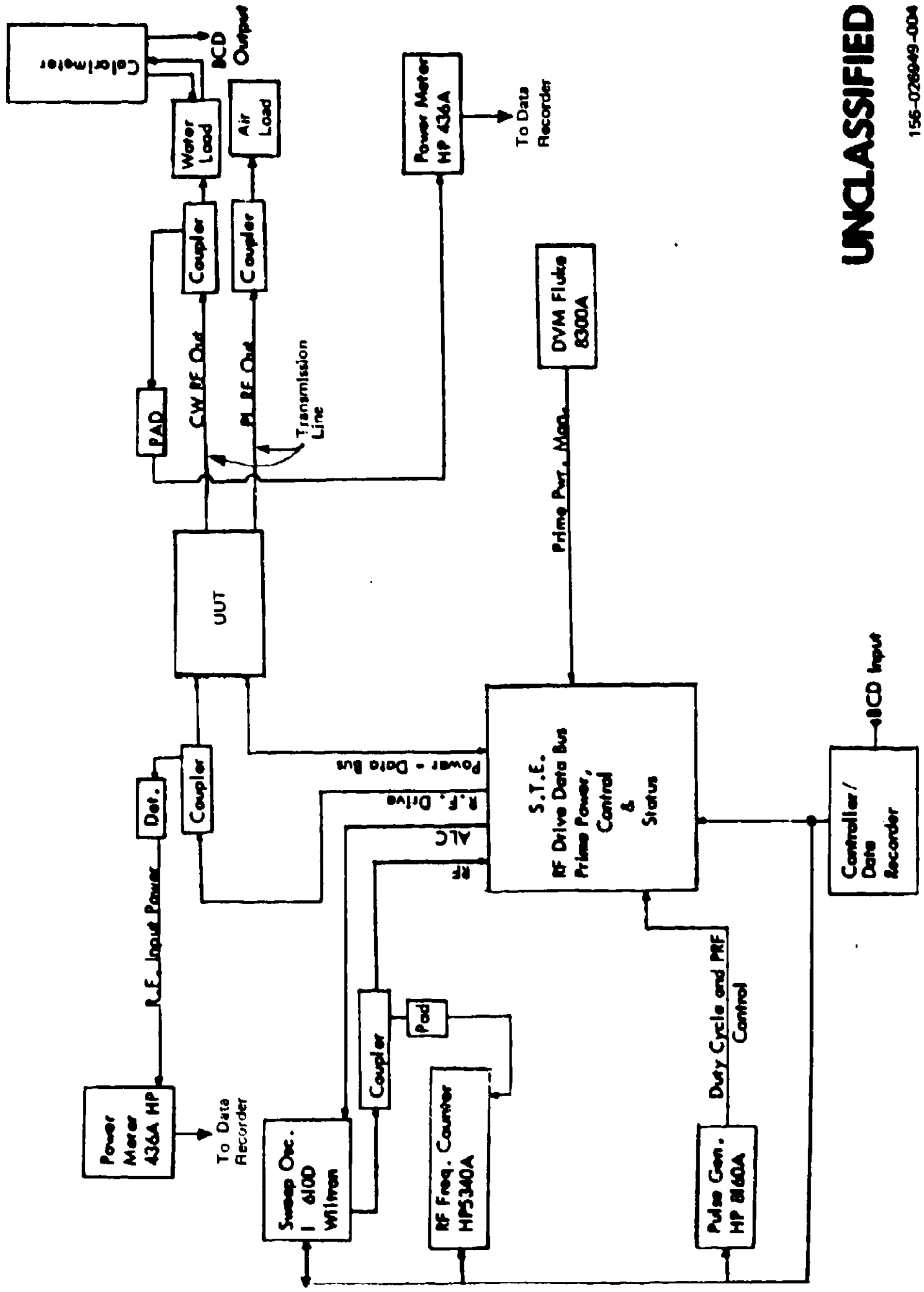
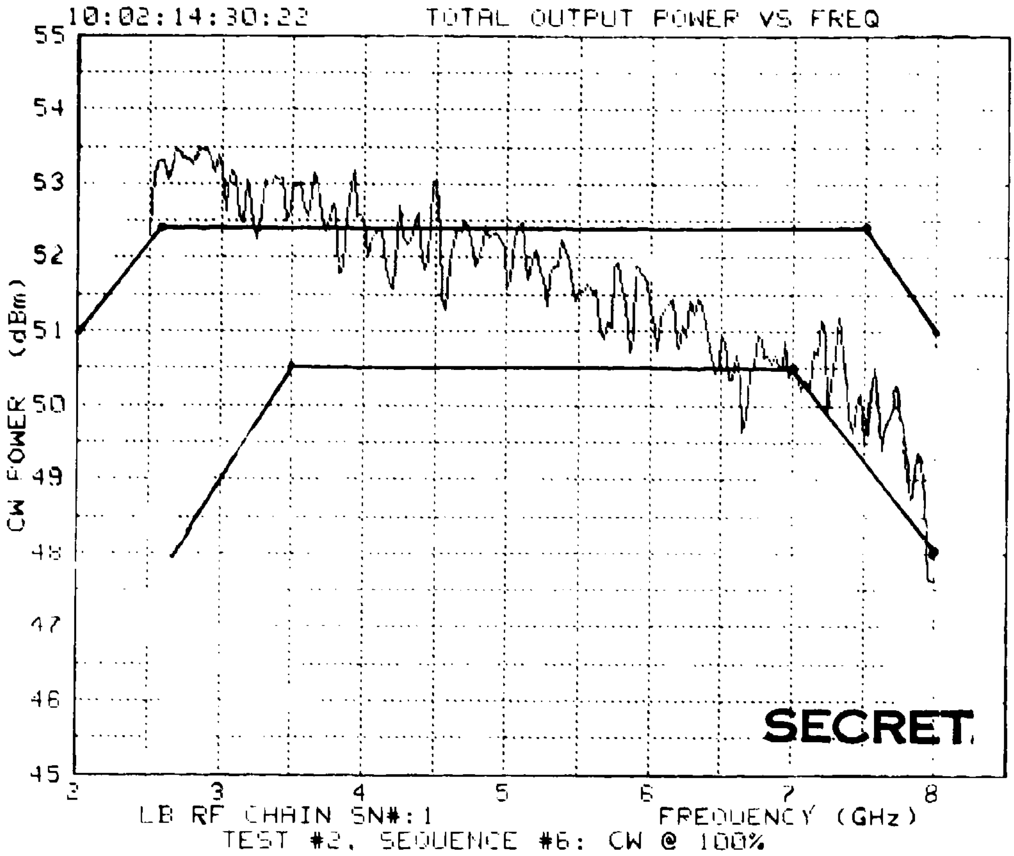
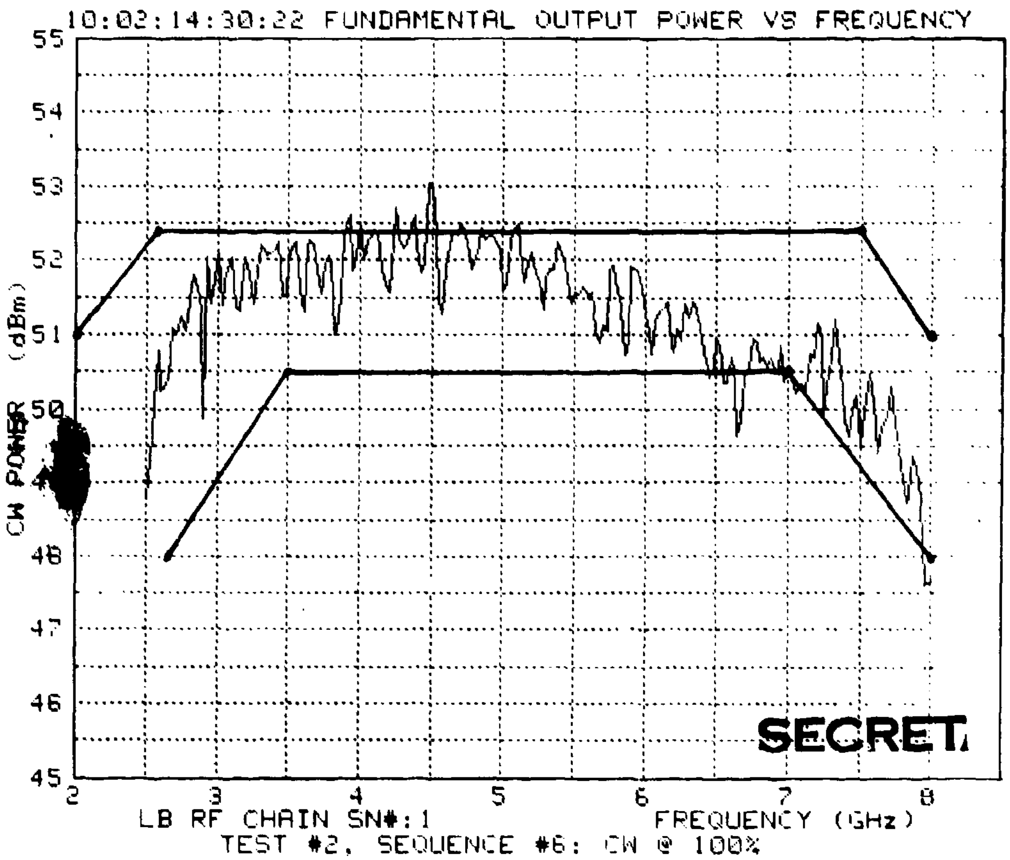



Figure 9. (U) RF Chain Output Power Test Setup.



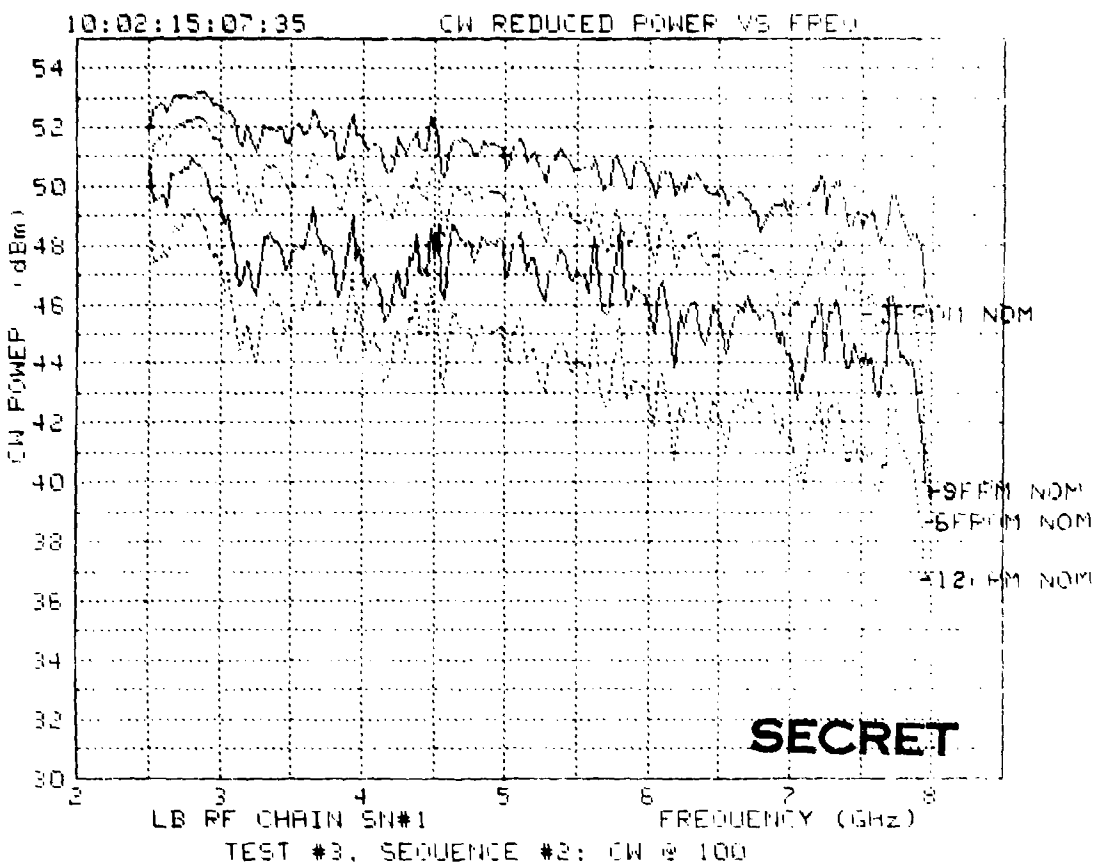

186-028864-010

Figure 10. (U) RF Chain Low Band, CW Total Power Output vs. Frequency, CW=100%.



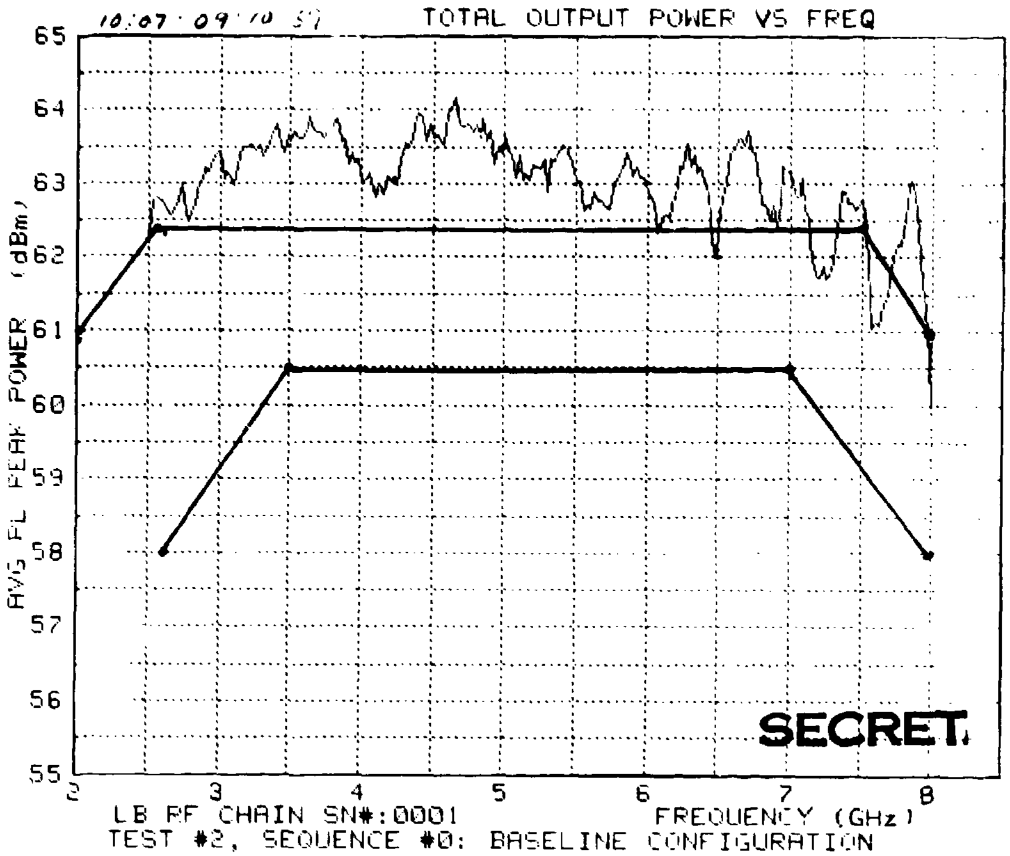

158-028864-011

Figure 11. (U) RF Chain Low Band, CW Fundamental Output Power vs. Frequency, CW=100%.



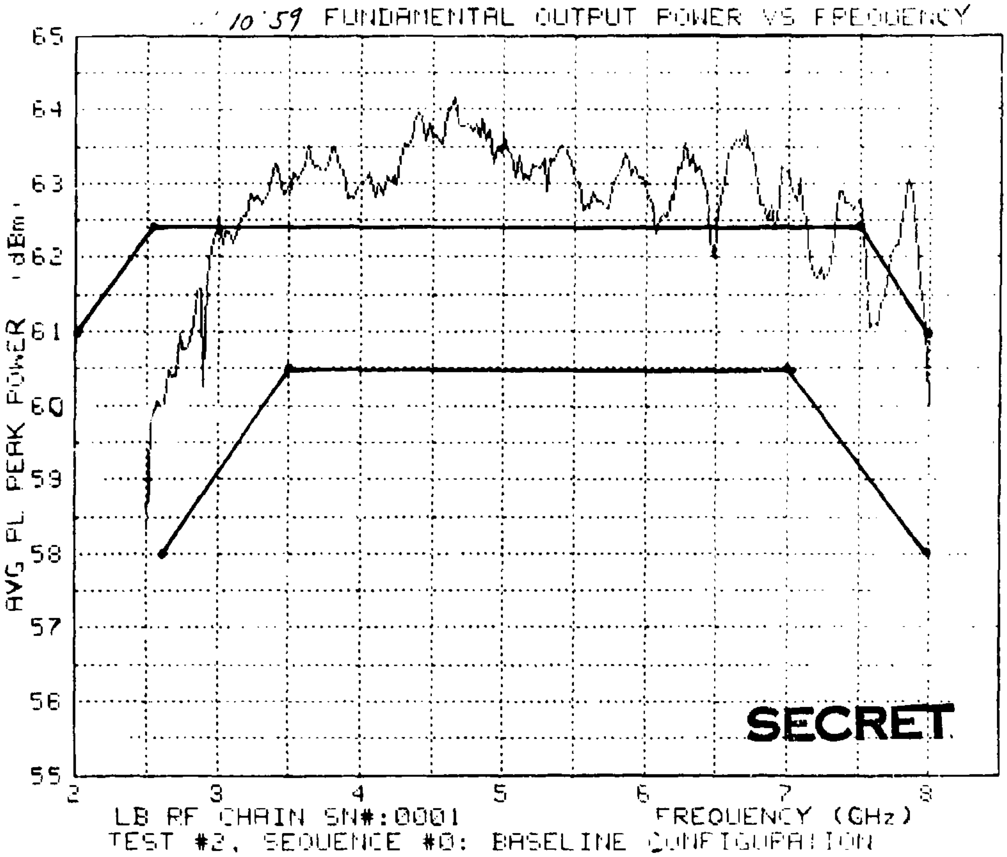

156-029664-012

Figure 12. (U) RF Chain Low Band, CW Reduced Power vs. Frequency, CW=100%.



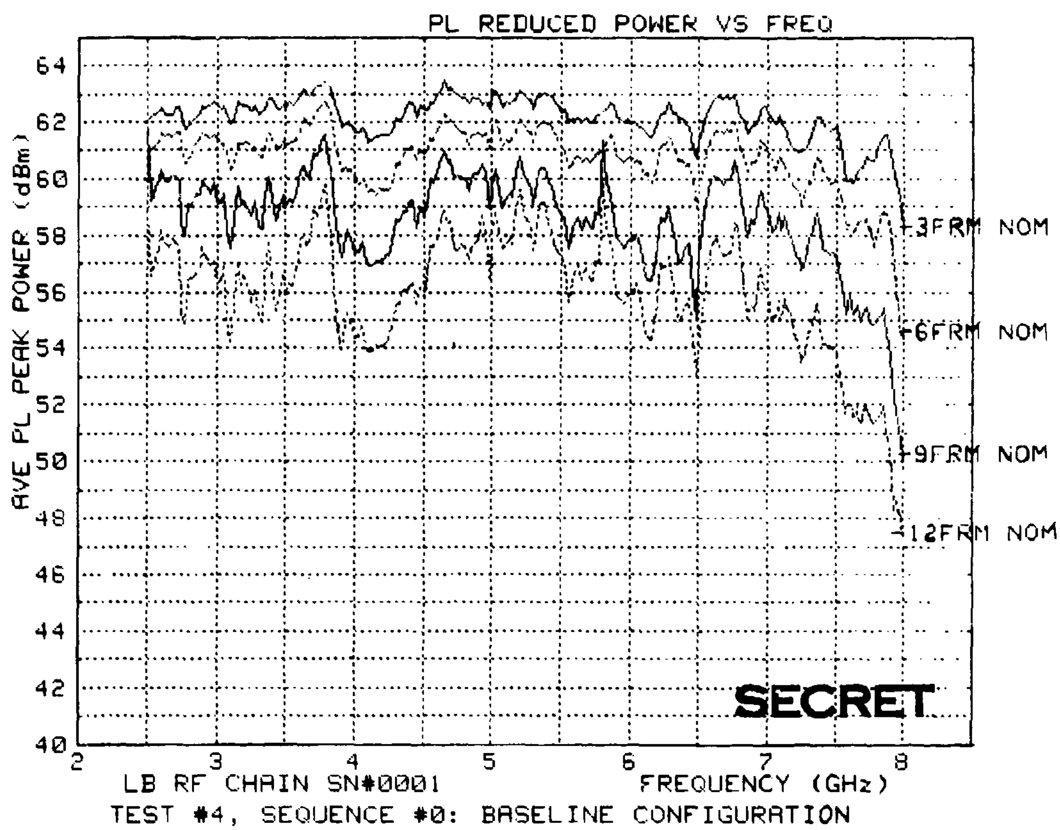

158-029864-013

Figure 13. (S) RF Chain Low Band, Pulse Total Output Power vs. Frequency, PLS = 25 us at 5%.




166-029664-014

Figure 14. (S) RF Chain Low Band, Pulse Fundamental Power Output vs. Frequency, PLS = 25 us at 5%.




180-020864-015

Figure 15. (S) RF Chain Low Band, Pulse Reduced Power vs. Frequency, PLS = 25 us at 5%.

(U) The CW output power exceeds the specifications to which the CW tube was designed, and meets a portion of the rf chain power requirements across the frequency band. Pulse output power exceeded the tube design specification. For total power output the pulse tube also exceeded the rf chain specification except for a 900 MHz area in the high end of the frequency band and the lower 500 MHz of the desired (goal) rf chain frequency range. The reduced drive level tests results shown that each TWT produces the same output power spectrum shape for various reduced drive levels.

3.2.2 (U) Small Signal Gain

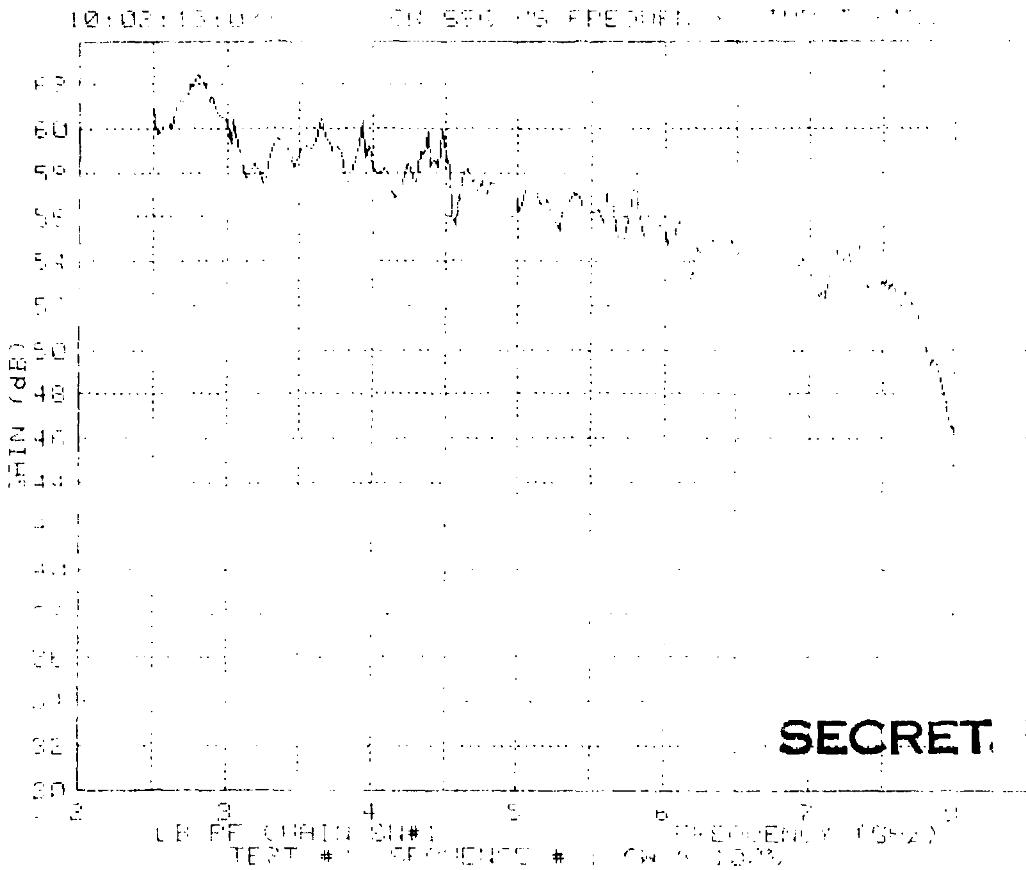
a. (U) Purpose. The purpose of this test is to demonstrate the small signal gain across the frequency band, with the rf input drive levels reduced by 15 dB from their nominal values. The test setup is shown in figure 9.

b. (S) Results: The tests were run with the input drive level 15 dB down from its nominal value. The results of this test are shown in figures 16 and 17. Here again the unit did not meet rf chain specifications (67 dB minimum for CW, 77 dB for pulse), but exceeded the tube design specifications (35 dB minimum for CW, 46 dB for pulse).

3.2.3 (U) Harmonic Power

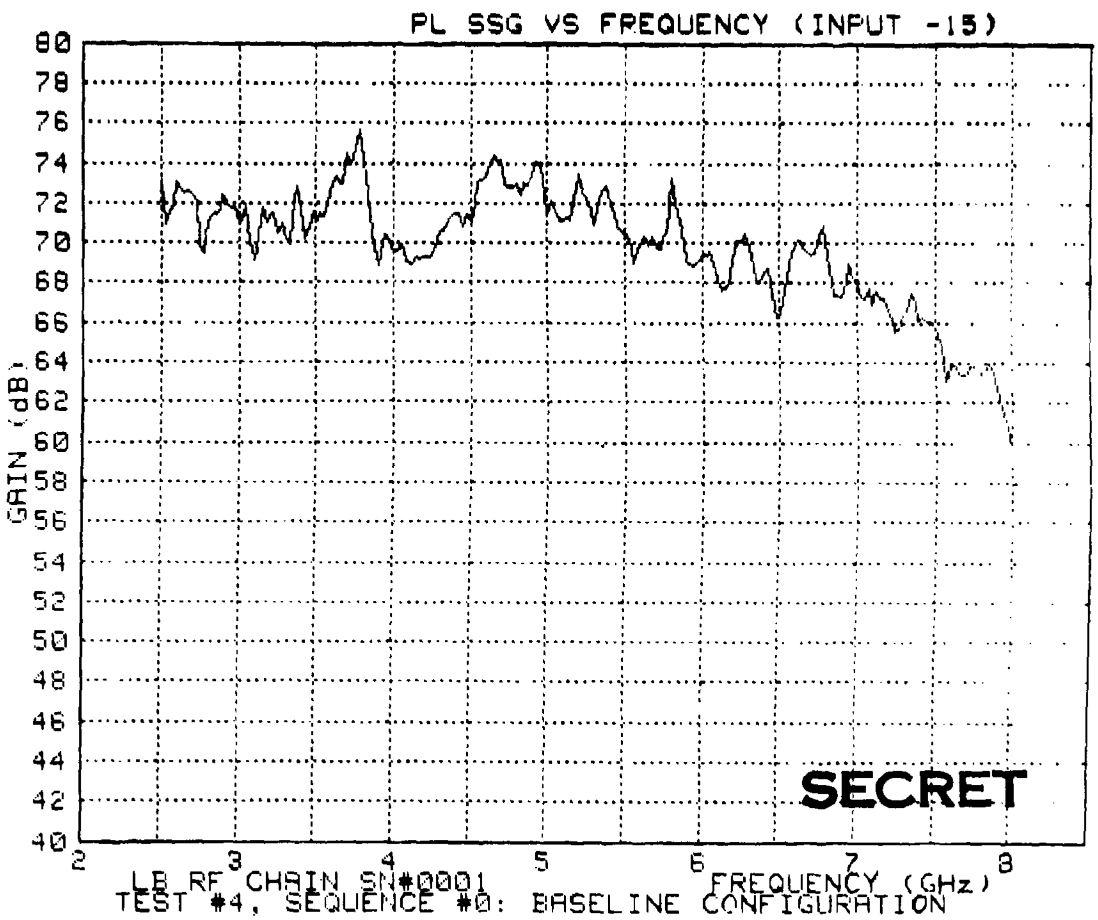
a. (U) Purpose. This test measured the relationship between the total output power and the harmonic power for harmonic outputs within the calibration frequency range.

b. (S) Results. The test was performed concurrently with the tests described in paragraph 3.2.1 (see figure 9). The results are shown in figures 18 and 19. The worst case harmonic power in the CW mode was -3.0 dBc, at 2.55 GHz and 2.85 GHz. This fulfills the rf chain requirements of a worst case second harmonic of -3 dBc to -4 dBc.



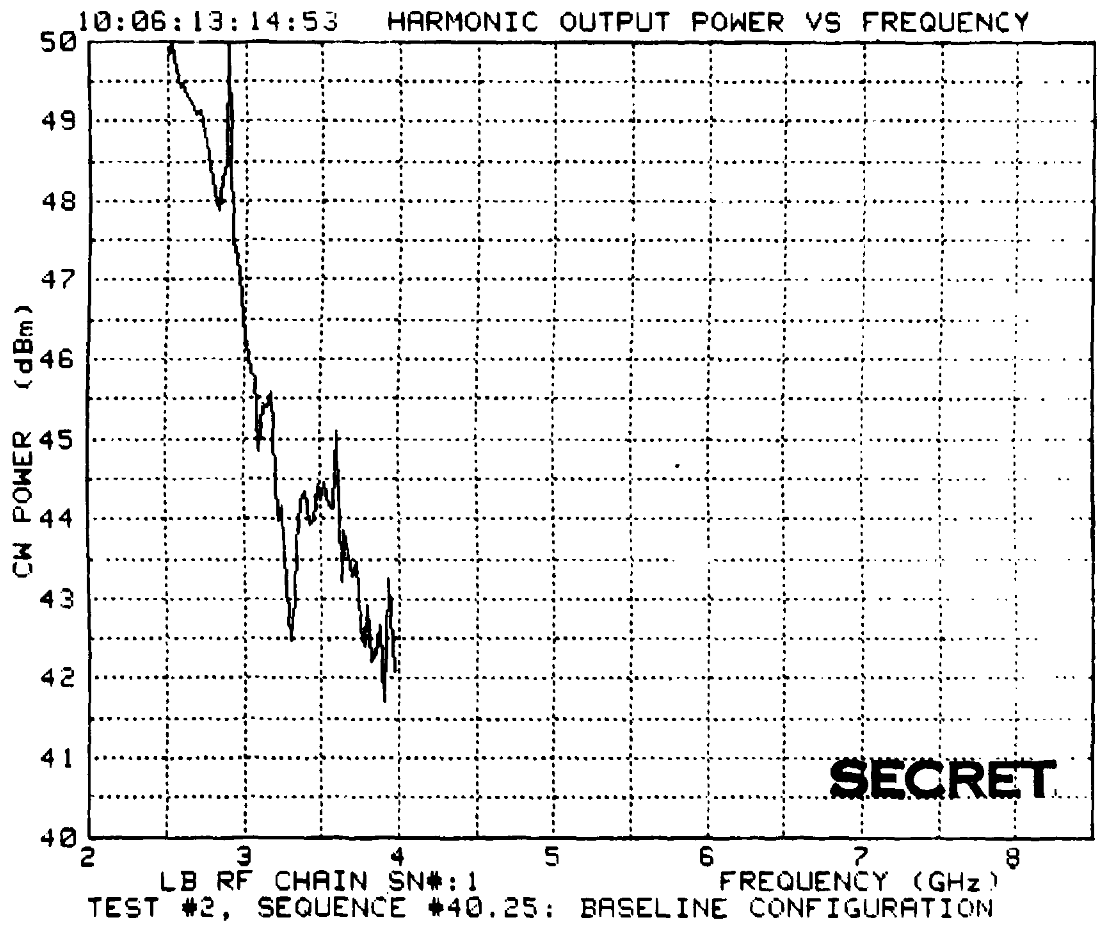

156-029664-016

Figure 16 (U) RF Chain Low Band, CW Small Signal Gain vs. Frequency, CW = 100%.



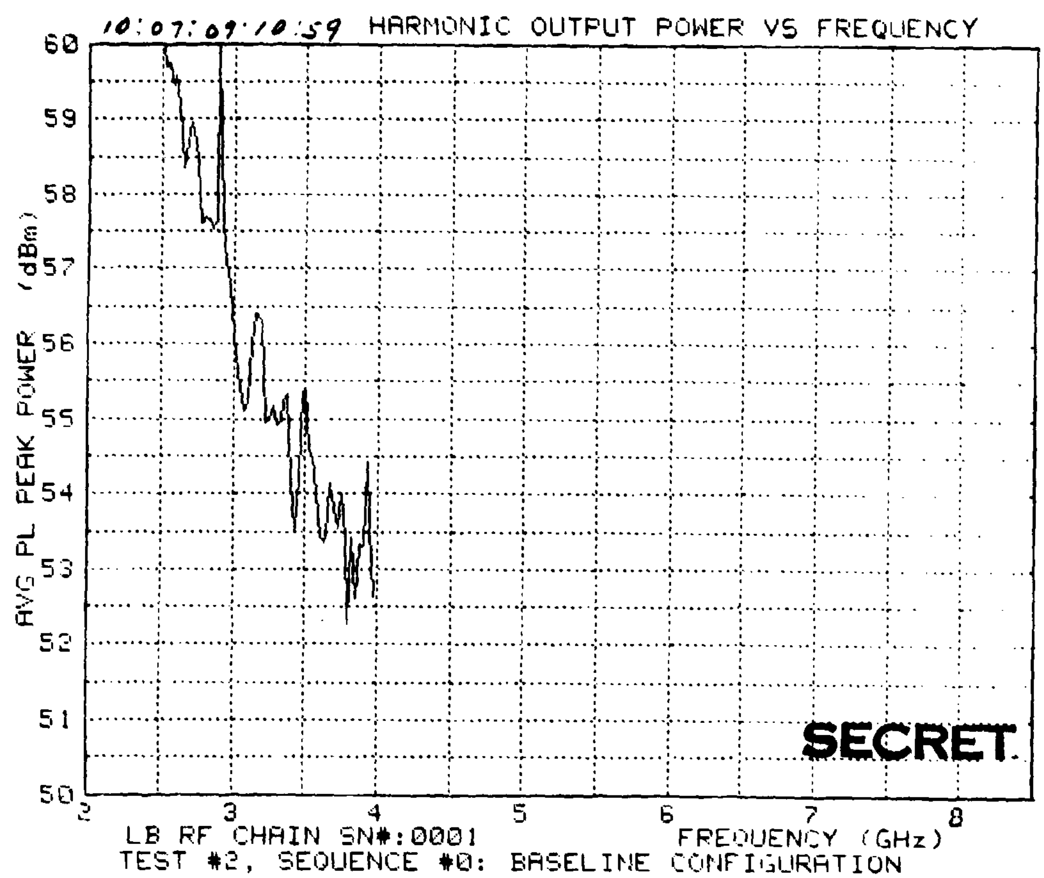

156-029664-017

Figure 17. (S) RF Chain Low Band, PL Small Signal Gain vs. Frequency, PLS = 25 us at 5%.




188-028884-018

Figure 18. (U) RF Chain Low Band, CW Harmonic Output Power vs. Frequency, CW = 100%.




156-029664-019

Figure 19. (S) RF Chain Low Band, PL Harmonic Output Power vs. Frequency, PLS = 25 us at 5%.

(S)The worst case harmonic power for the pulse tube was -2.5 dBc at 2.55 GHz. This is total harmonic power. The rf chain also fulfills the requirements for the typical second harmonic to be -10 dBc.

3.2.4 (U) Spurious Outputs and Noise Power

a. (U) Purpose. The purpose of this test is to demonstrate that the Unit Under Test (UUT) meets the spurious noise output requirements. The test setup is shown in figure 20.

b. (C) Results. This test was conducted in accordance with paragraph 8.3.2.2 of the rf chain test plan. The results are shown in data sheet 8.3.2 (figure 21). The requirements are -3 dBm/MHz maximum for CW and 40 dBm maximum for pulse. No spurious outputs exceeded specification.

3.2.5 (U) TWT Transfer Characteristics

a. (U) Purpose. The purpose of this test is to show the relationship between the rf input drive into the rf chain LRU and the output power of the LRU. This information is supplied as supplemental information to required test data.

b. (U) Results. The test configuration is shown in figure 9. The test results are shown in figures 22 through 30. They show very linear transfer characteristics up to the saturation point of the TWTs.

3.2.6 (U) Mismatched Loads

a. (U) Purpose. This test was performed to determine the effect on rf chain power output of operating into a load that presents a less than optimum impedance match. The test setup is shown in figure 31.

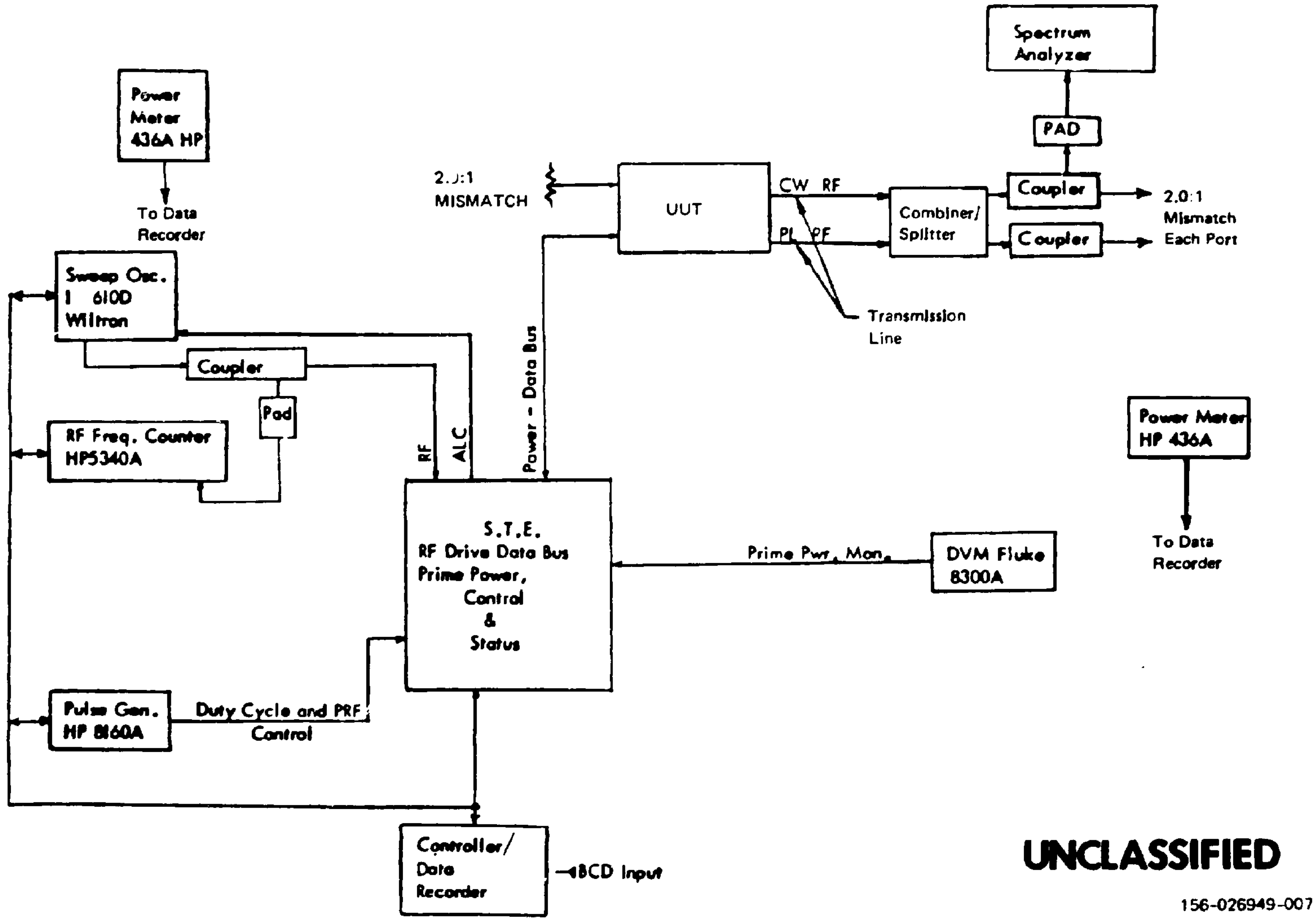



Figure 20. (U) RF Chain Unit, Spurious Signal Test Setup.

SPURIOUS OUTPUTS
Data Sheet 8.3.2

RF CHAIN Low Band DATE 10-8-81

Base Line CONFIGURATION

| | BLANK | CW | PL |
|---|---|---|---|
| LOW BAND EDGE | -71dB | -66 dB | -68 dB |
| MID BAND | -68 dB | - 58 dB | -62 dB |
| HIGH BAND EDGE | -68 dB | - 66 dB | - 68 dB |

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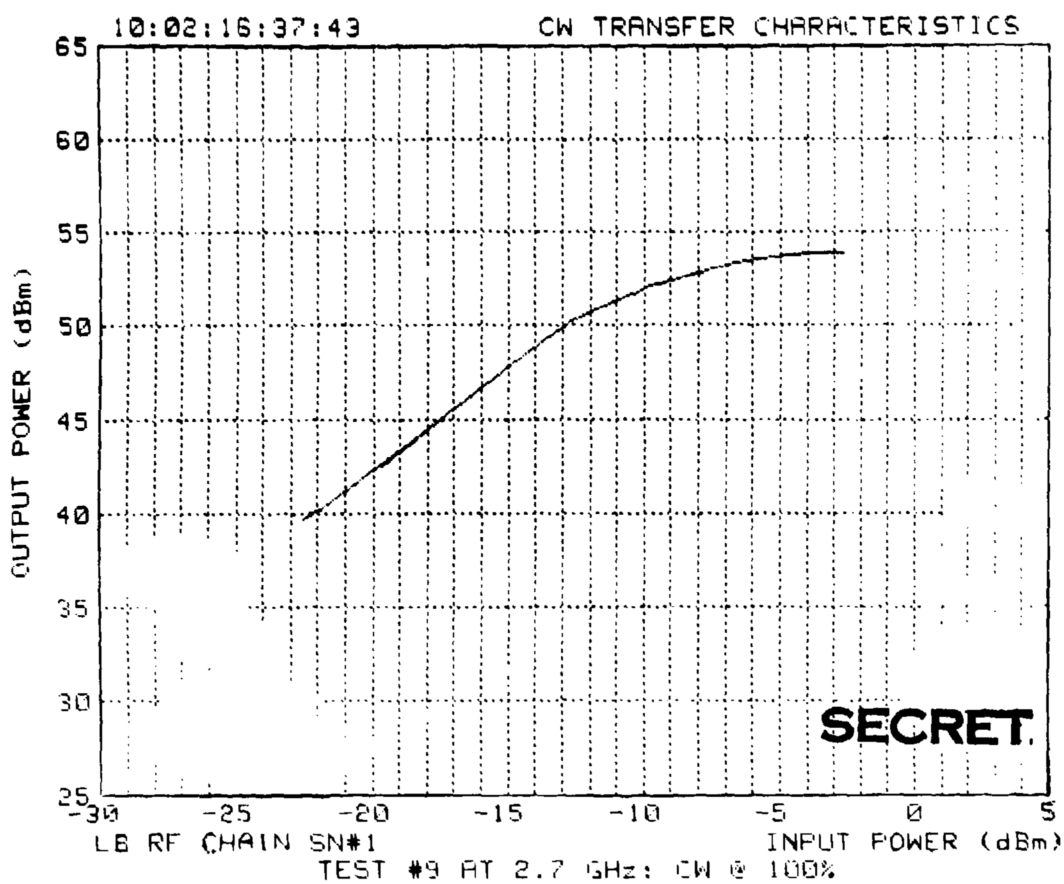
Figure 21. (U) RF Chain Low Band, Spurious Outputs.




156-029864-022

Figure 22. (U) RF Chain Low Band, CW Transfer Characteristics at 2.7 GHz, CW = 100%.

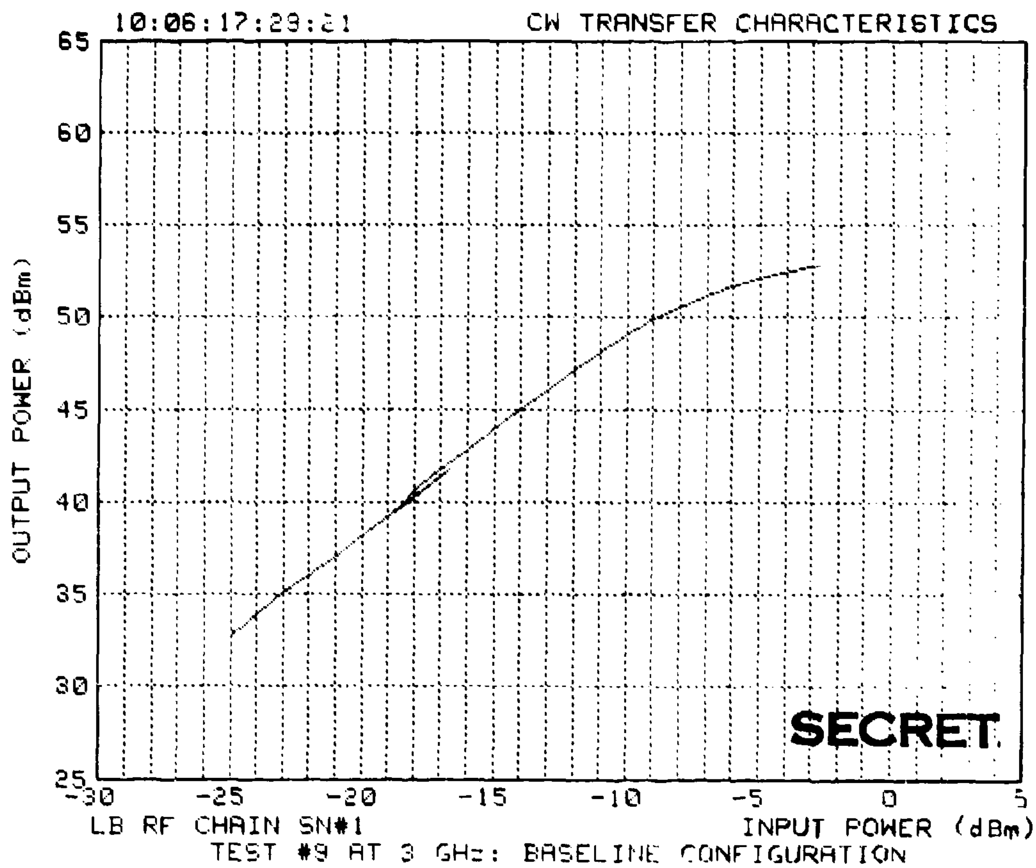
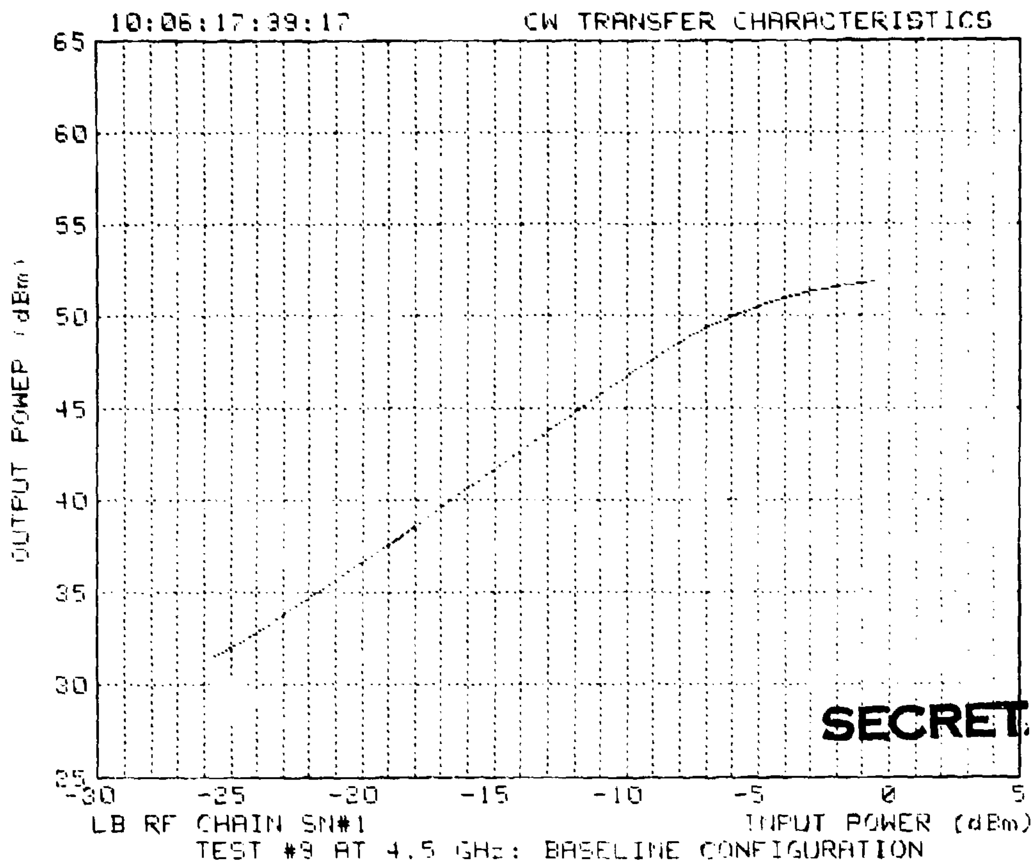
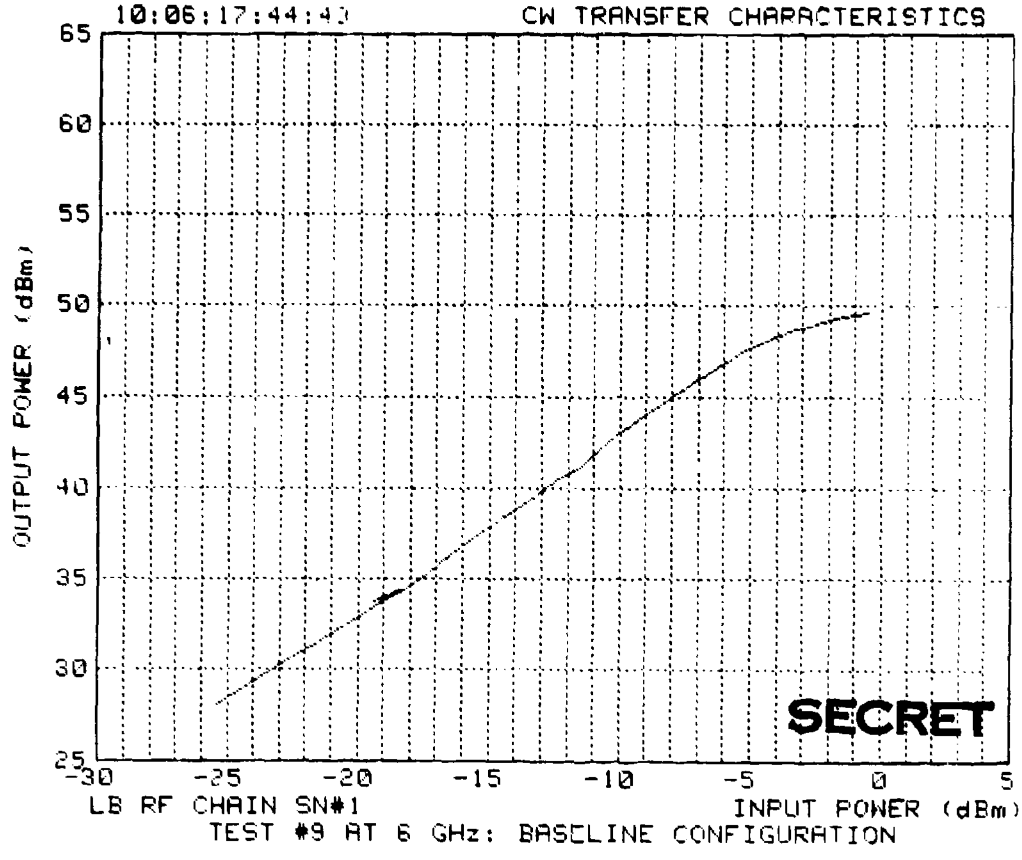



Figure 23. (U) RF Chain Low Band, CW Transfer Characteristics at 3 GHz, CW = 100%.



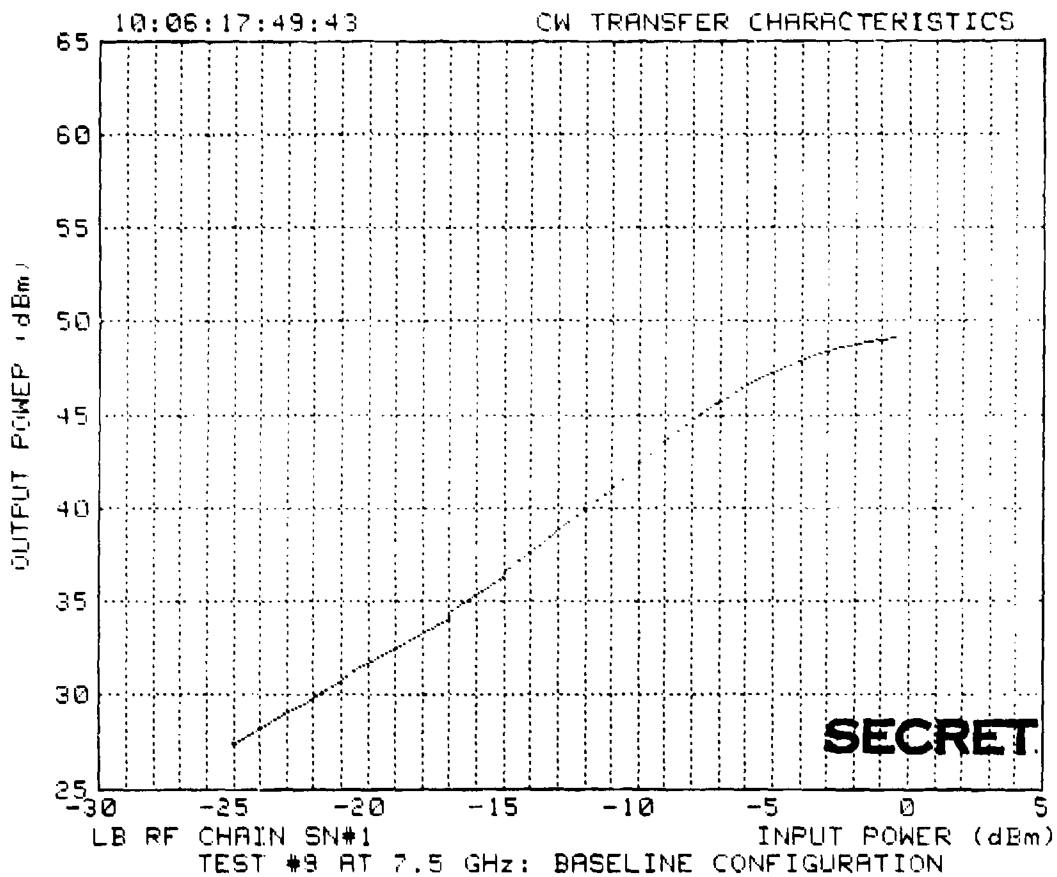

186-029664-024

Figure 24. (U) RF Chain Low Band, CW Transfer Characteristics at 4.5 GHz, CW = 100%.



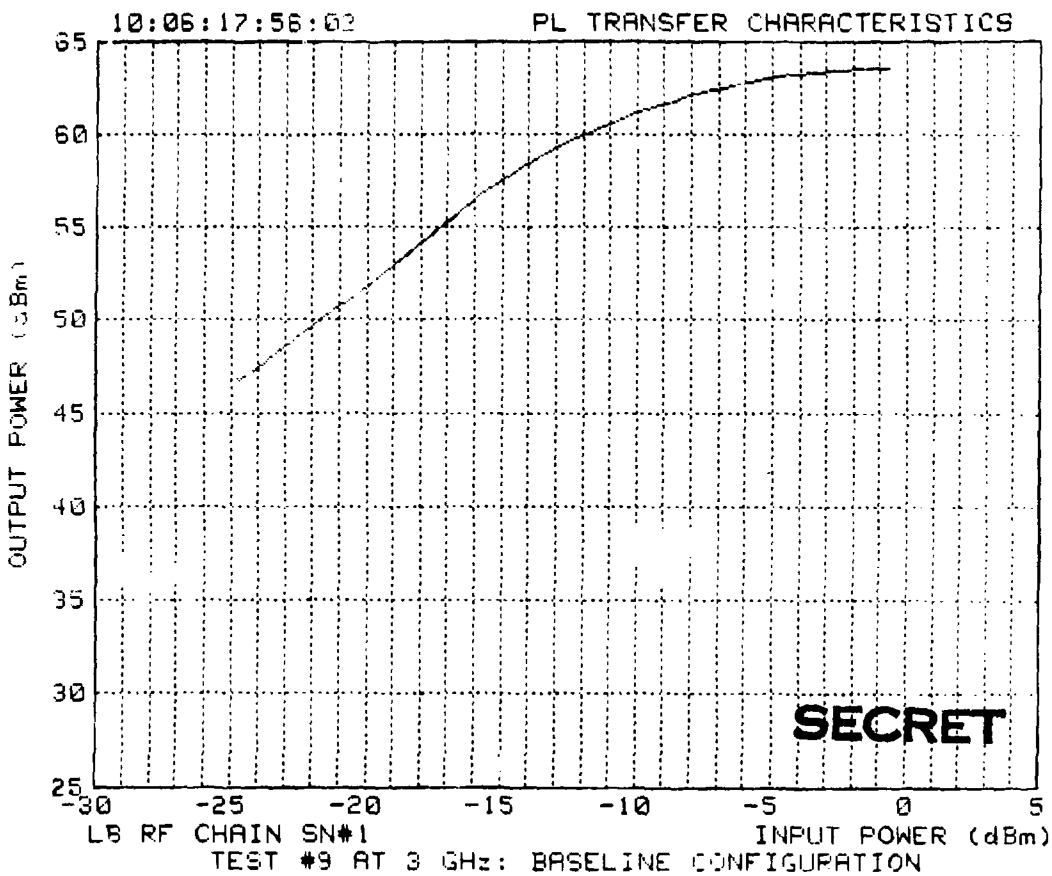

186-029864-026

Figure 25. (U) RF Chain Low Band, CW Transfer Characteristics at 6 GHz, CW = 100%.




156-029664-026

Figure 26. (U) RF Chain Low Band, CW Transfer Characteristics at 7.5 GHz, CW = 100%.




186-028884-027

Figure 27. (S) RF Chain Low Band, PL Transfer Characteristics at 3 GHz, PLS = 25 us at 5%.

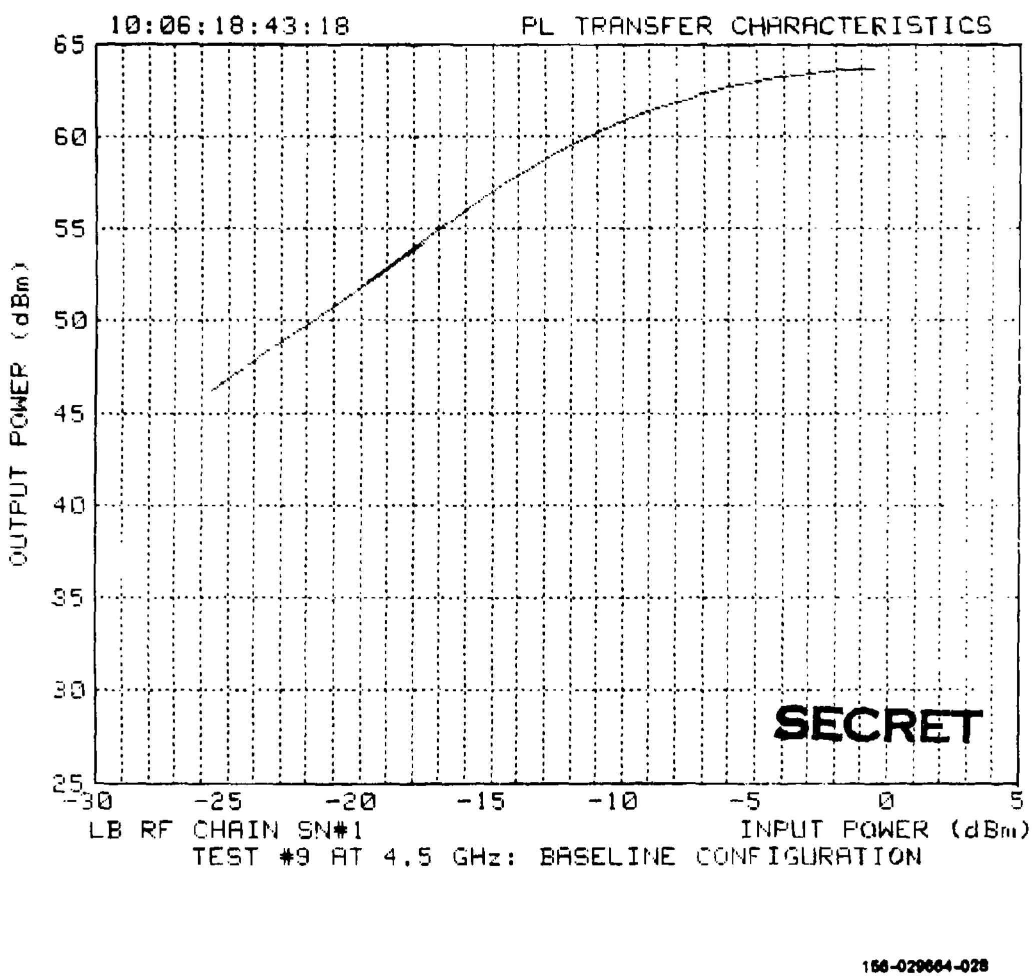
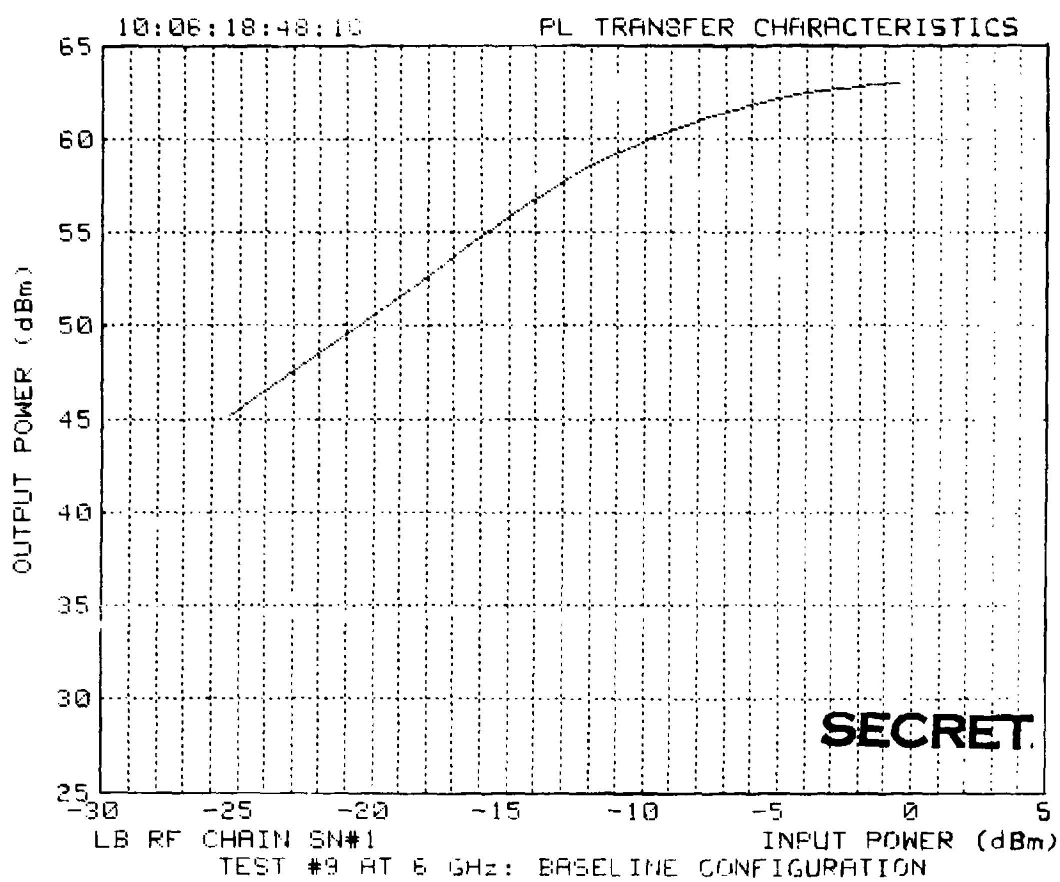
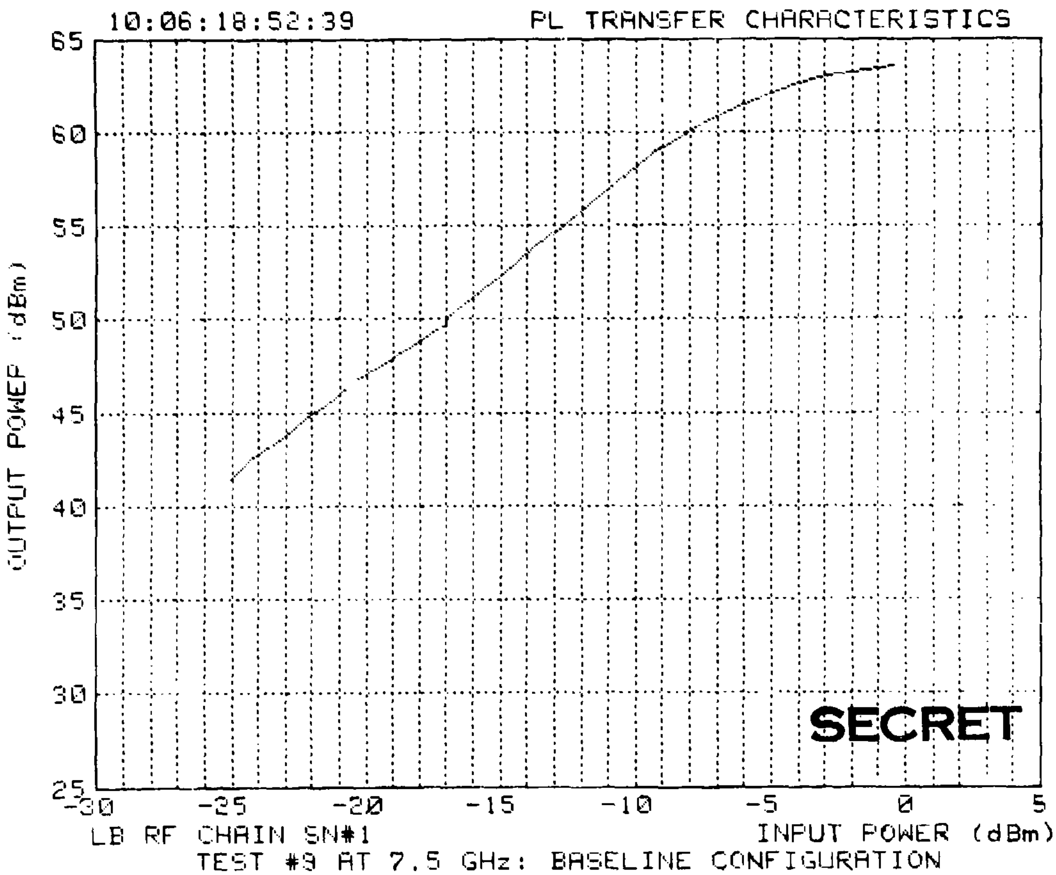



Figure 28. (S) RF Chain Low Band, PL Transfer Characteristics at 4.5 GHz, PLS = 25 us at 5%.




156-029664-029

Figure 29. (S) Chain Low Band, PL Transfer Characteristics at 6 GHz, PLS = 25 us at 5%.




156-029664-030

Figure 30. (S) RF Chain Low Band, PL Transfer Characteristics at 7.5 GHz, PLS = 25 us at 5%.

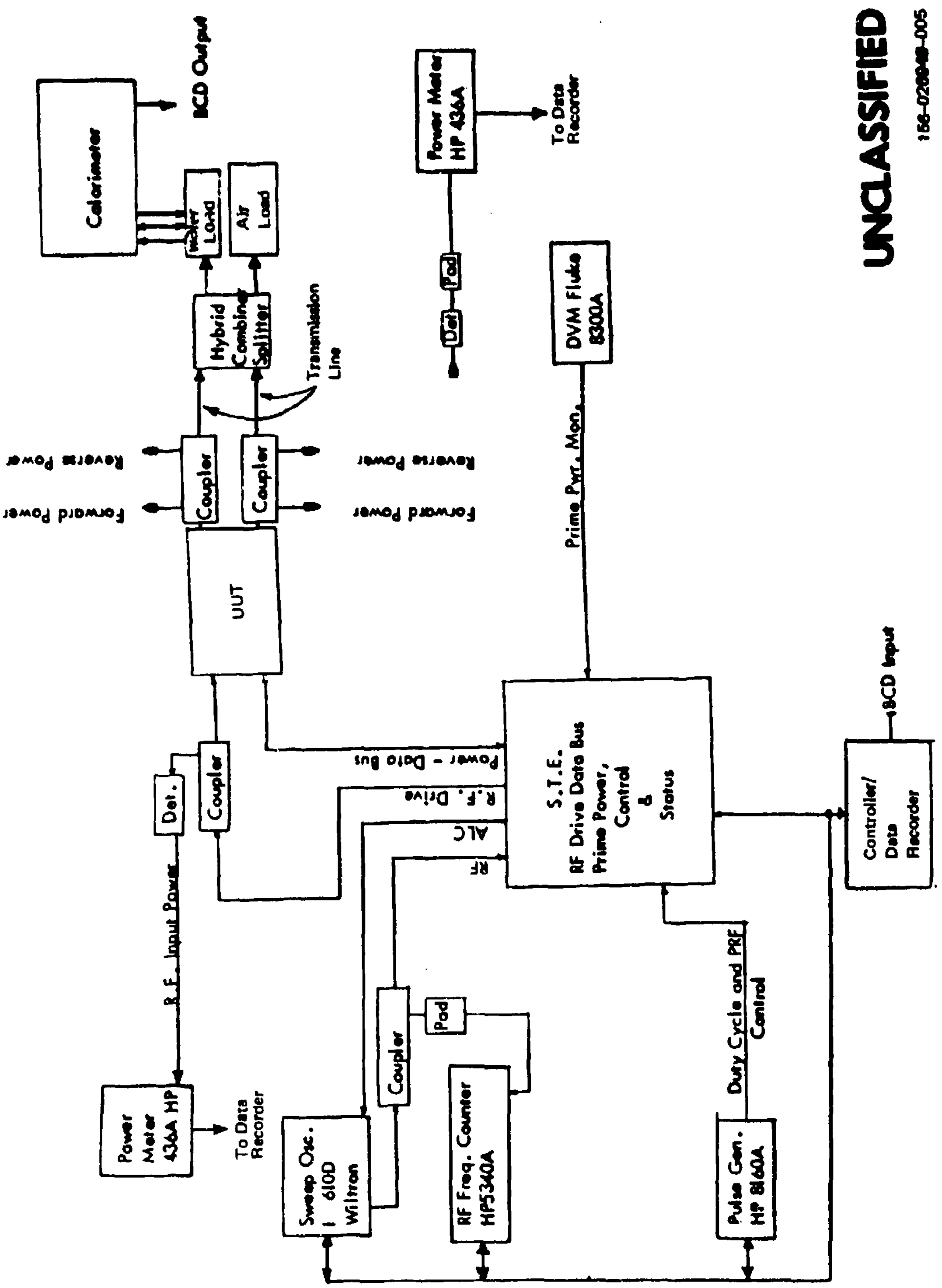



Figure 31. (U) RF Chain Unit Power Output with Combiner/Splitter.

b. (C) Results. The rf chain is required to operate into loads with a VSWR of 2:1. This test was performed with a 2:1 mismatch of random phase to simulate a worst case feed line and antenna loading condition. The test results are shown in figures 32 and 33. The CW output power showed a maximum decrease of 0.83 dB, and the pulse output power showed a maximum decrease of 0.7 dB.

3.2.7 (U) Propagation Delay

a. (U) Purpose. The purpose of this test is to demonstrate the pulse repeater response of the RF Chain Power Amplifier LRU. The time measured is from the receipt (3.5 - volt level of the leading edge) of the real time video command to the 90% voltage point of the detected output pulse. The test setup is shown in figure 34.

b. (U) Results. The results of this test are listed on data sheet 8.3.4 (figure 35) and shown in the photographs of figure 36. The propagation delay specification is 75-100 ns. Both the pulse and the CW response times were within this specification. Both responses also meet the rf output pulse use time specification of 20 ns maximum.

3.2.8 (U) Mode Switching Time

a. (U) Purpose. The objective of the mode switching time test is to measure the response of the UUT during different combinations of timing sequences for CW, pulse, and blank modes. The test setup is shown in figure 37.

b. (U) Variations in Procedure. A single pulse generator setup for double pulse output was used instead of the two pulse generator setup called for in table 1 of the rf chain test plan (shown in figure 38).

10:07:10:35:17 LB RF CHAIN SN#0001

TEST #7, SEQUENCE #0: BASELINE CONFIGURATION

RESULTS OF MATCHED LOADS CW

| FREQUENCY (GHz) | OUTPUT POWER (dBm) |
|---|---|
| 2.7 | 53.3 |
| 4.75 | 52.46 |
| 7.8 | 49.35 |

RESULTS OF MISMATCHED LOADS CW

| FREQUENCY (GHz) | OUTPUT POWER (dBm) |
|---|---|
| 2.7 | 53.69 |
| 4.75 | 52.6 |
| 7.8 | 48.48 |

SECRET
156-029864-032

Figure 32. (S) RF Chain Low Band, Mismatched Loads Test, CW = 100%.

10:07:11:07:46 LB RF CHAIN SN#0001

TEST #7, SEQUENCE #0: BASELINE CONFIGURATION

RESULTS OF MATCHED LOADS PL

| FREQUENCY (GHz) | OUTPUT POWER (dBm) |
|---|---|
| 2.7 | 63.25 |
| 4.75 | 64.13 |
| 7.8 | 62.87 |

RESULTS OF MISMATCHED LOADS PL

| FREQUENCY (GHz) | OUTPUT POWER (dBm) |
|---|---|
| 2.7 | 62.94 |
| 4.75 | 63.94 |
| 7.8 | 62.89 |

SECRET

156-029864-033

Figure 33. (S) RF Chain Low Band, PL Mismatched Loads Test, PLS = 25 us at 5%.

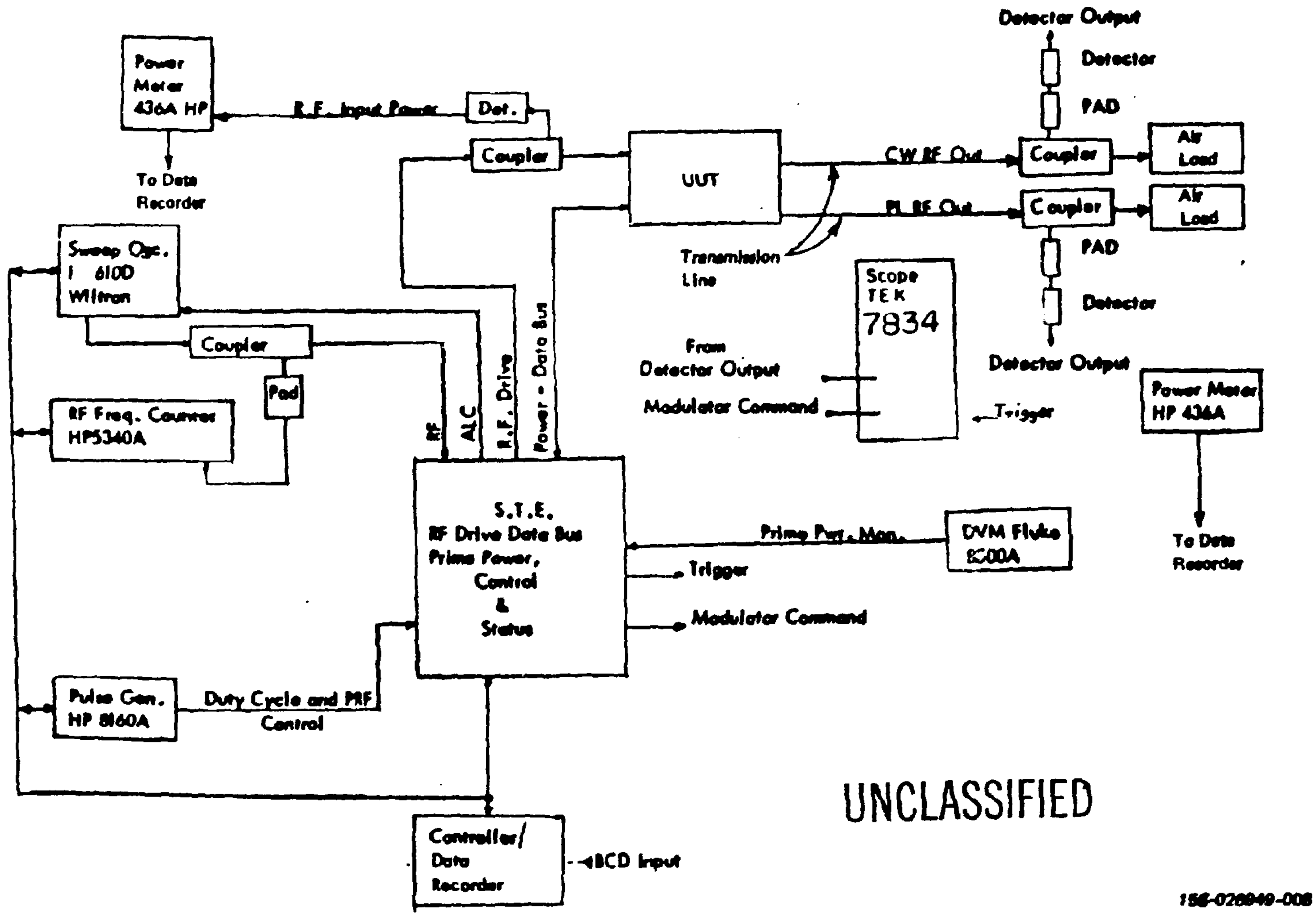



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Figure 34. (U) RF Chain Unit Response to Command Modulator Test Setup.

PROPAGATION DELAY

RF CHAIN Low Band DATE 10/8/81

BaseLine CONFIGURATION

| MODE OF OPERATION | VIDEO COMMAND T = 0 (3.5V LEVEL) | (90% Point) OUTPUT PULSE | DELAY TIME |
|---|---|---|---|
| CW | 0 | 100 NS | 30 NS |
| PL | 0 | 75 NS | NS |

IN PL, Rise Time of Detected RF Output 15NS

IN CW. Rise Time of Detected RF Output ZONE

156-029664-035

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TEST ENGINEER ______ DATE ______

Q.A. ______ DATE ______

DCAS ______ DATE ______

Figure 35. (U) RF Chain Low Band, Propagation Delay.


156-029664-036X

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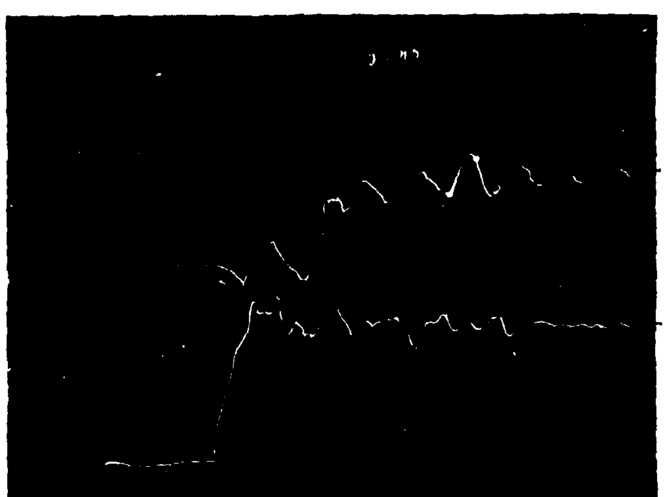
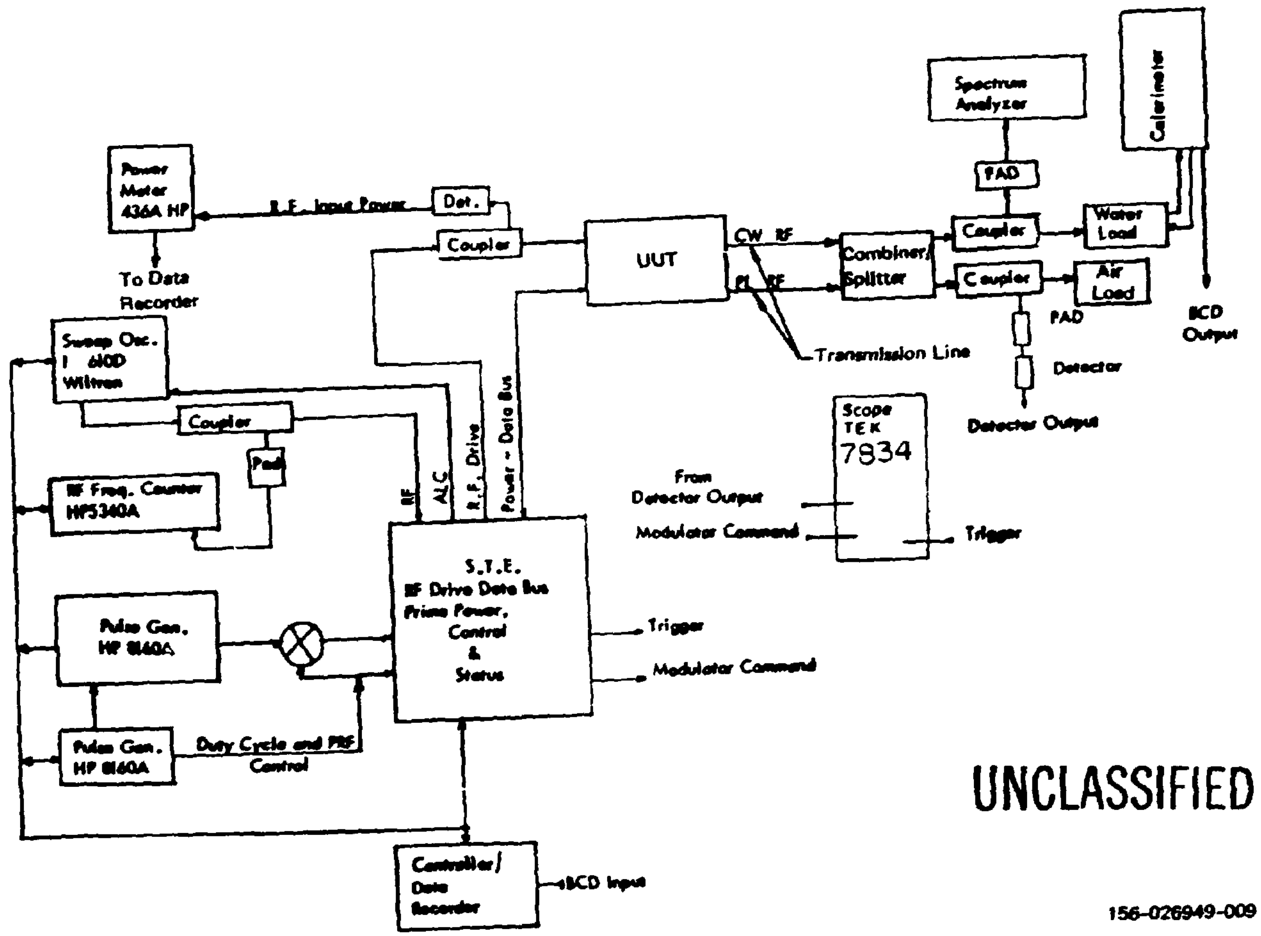



156-029664-036

CONFIDENTIAL

Figure 36. (U) RF Chain Low Band, Propagation Delay.

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156-026949-009

Figure 37. (U) RF Chain Unit, Duty Cycle Limiting and Mode Switching Time Test Setup.

| | Pulse Operation | | CW Operation | |
|---|---|---|---|---|
| | Pulse width | PRI | Pulse width | PRI |
| Pulse Generator #1 | 1 us | 100 us | 2 us | 100 us |
| Pulse Generator #2 | 1 us | 100 us | 2 us | 100 us |

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Figure 38. (U) RF Chain Unit, Mode Switching Time.

c. (C) Results. The mode switching time set was performed in the CW and pulse modes of operation. The pulse generator was programmed for double pulse output, and the pulse separation was adjusted to the point at which the detected rf output pulse separation was at a minimum (see data sheet 8.3.4.1, figure 39). A mode switching time of 75 - 100 ns is required. The results in figure 40 show a mode switching time of about 200 ns.

3.2.9 (U) Primary Power

a. (U) Purpose. The objective of the primary power test is to measure the warmup time of the UUT and to determine the input power requirements at high line, low line, and nominal input voltage settings. Additionally, this test will verify the prorated warmup time after a primary power interrupt.

b. (U) Results. The test setup is shown in figure 41. The warmup time was found to be 187 seconds. The prorated warmup time was 2 seconds of warmup time for each second of interrupt time, for up to 90 seconds of interrupt time. After 90 seconds of primary power interrupt time, a full warmup time is required.

(U) The primary power requirement is three phase, 400 Hz supply at 115 V ±5%. The maximum input power specified is 800 watts per tube. The results (figures 42 through 45) show that the minimum primary power is always maintained; and while the CW tube sometimes exceeds 800 watts, the pulse tube never does, and the total power requirements never exceed 1600 watts for both tubes.

3.2.10 (U) Response to Commands

a. (U) Purpose. The purpose of this test is to verify that the UUT operates in all modes, responds to digital commands, and that it generates and processes proper status information whenever status is requested.

MINIMUM PULSE SEPARATION
Data Sheet 8.3.4.1

RF CHAIN Low Band DATE 10-8-81

Baseline CONFIGURATION

| MODE OF OPERATION | PULSE WIDTH | DBL | SEPARATION |
|---|---|---|---|
| CW | 500 nsec. | 826 nsec | 326 nsec |
| PC | 500 nsec. | 826 nsec | 326 nsec. |

156-029664-039

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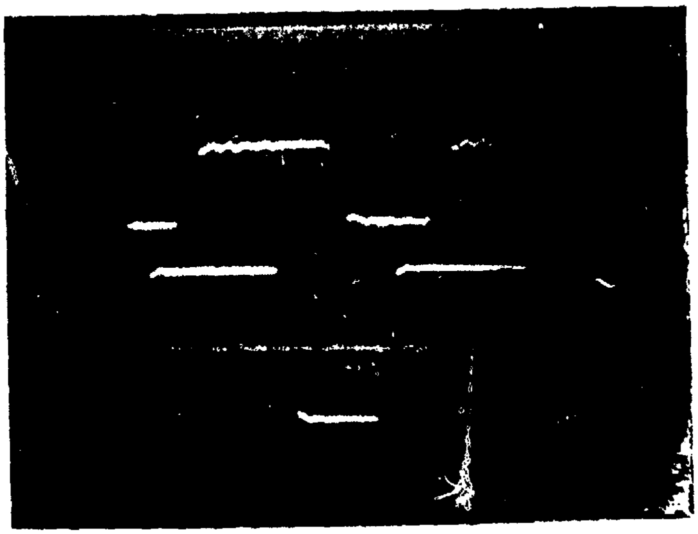
TEST ENGINEER ________ DATE ________

Q.A. ________ DATE ________

DCAS ________ DATE ________

Figure 39. (U) RF Chain Low Band, Minimum Pulse Separation.

[illegible] PULSE SEPARATION

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[illegible] SEPARAT[illegible]


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**CONFIDENTIAL**

Figure [illegible] RF Chain [illegible] Mode [illegible] Test

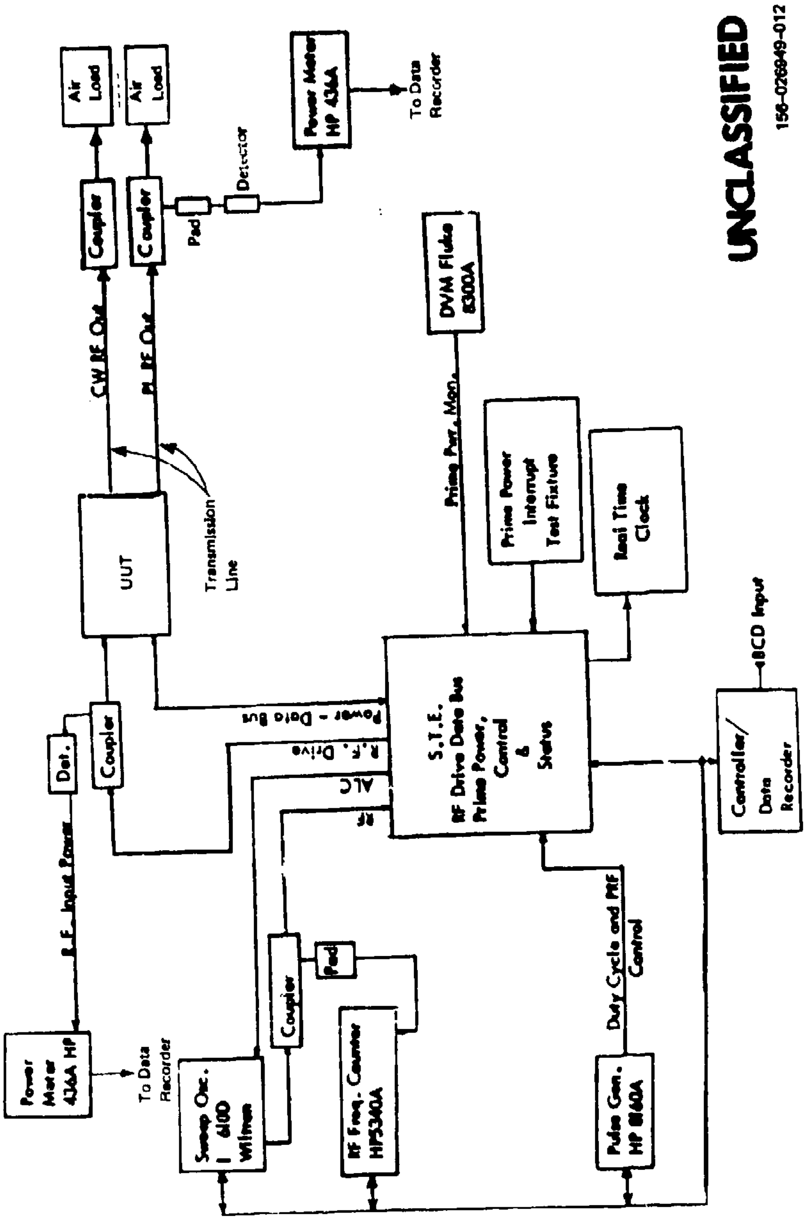


Figure 41. (U) RF Chain Unit, Primary Power, Test Setup.

PRIMARY POWER

Data Sheet 8.3.5.2.a
— 42

RF CHAIN Low Band DATE 10-8-81

Baseline CONFIGURATION

MODE OF OPERATION ST'BY

| LOW LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER watts | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 107.75 | 1.09 | 117.45 | 55.2 | | |
| Ø B | 108.1 | 1.09 | 117.83 | 58.4 | | |
| Ø C | 107.7 | 1.03 | 110.93 | 51.95 | | |
| TOTAL | — | — | 346.21 | 165.55 | -0- | -0- |

MODE OF OPERATION ST'BY

| NOMINAL LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER watts | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 115.5 | 1.11 | 128.21 | 55.25 | | |
| Ø B | 116.25 | 1.13 | 131.36 | 60.60 | | |
| Ø C | 115.35 | 1.07 | 123.42 | 54.95 | | |
| TOTAL | — | — | 382.99 | 170.8 | -0- | -0- |

MODE OF OPERATION ST'BY

| HIGH LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER watts | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 118.4 | 1.14 | 134.98 | 59.4 | | |
| Ø B | 118.5 | 1.11 | 131.54 | 58.95 | | |
| Ø C | 117.2 | 1.09 | 127.75 | 54.95 | | |
| TOTAL | — | — | 394.259 | 173.3 | -0- | -0- |

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Figure 42. (U) RF Chain Low Band, Primary Power.

PRIMARY POWER

Data Sheet 8.3.5.2.d

RF CHAIN Low Band DATE 10-8-81

Baseline CONFIGURATION

MODE OF OPERATION CW + PL  PL 25 μsec OFF 3 μsec CW 69 μsec OFF 3 μsec

| LOW LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 105.5 | 4.69 | 494.8 | 441.8 | | |
| Ø B | 105.9 | 4.83 | 511.5 | 458.7 | | |
| Ø C | 105.3 | 4.69 | 493.86 | 439.5 | | |
| TOTAL | — | — | 1500.15 | 1340 | -0dBm | 86w |

PL 25 μsec OFF 3 μsec CW 69 μsec OFF 3 μsec

MODE OF OPERATION CW+PL

| NOMINAL LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 113.7 | 4.47 | 508.24 | 445.0 | | |
| Ø B | 114.2 | 4.57 | 521.89 | 461.4 | | |
| Ø C | 113.6 | 4.35 | 49373 | 430.1 | | |
| TOTAL | ~ | ~ | 1523.86 | 1336.5 | -0dBm | 86w |

MODE OF OPERATION CW+PL

| HIGH LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 117.7 | 4.31 | 507.29 | 444.8 | | |
| Ø B | 117.4 | 4.33 | 508.34 | 446.0 | | |
| Ø C | 117.6 | 4.32 | 508.03 | 445.3 | | |
| TOTAL | ~ | ~ | 1523.66 | 1336.1 | -0dBm | 84w |

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Figure 43. (U) RF Chain Low Band, Primary Power.

PRIMARY POWER

Data Sheet 8.3.5.2.c

RF CHAIN Low Band DATE 10-8-81

Baseline CONFIGURATION

MODE OF OPERATION PL 5% 500 μsec PRI 25 μsec width

| LOW LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER watt | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 107.4 | 2.66 | 285.68 | 229.1 | | |
| Ø B | 108.4 | 2.74 | 297.02 | 243.1 | | |
| Ø C | 107.9 | 2.61 | 281.62 | 227.1 | | |
| TOTAL | — | — | 864.32 | 699.3 | -0 dBm | 34 watts |

MODE OF OPERATION PL 5% 500 μsec. PRI 25 μsec width

| NOMINAL LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 114.5 | 2.66 | 304.57 | 240.7 | | |
| Ø B | 114.3 | 2.63 | 300.61 | 238.6 | | |
| Ø C | 113.7 | 2.55 | 289.94 | 226.7 | | |
| TOTAL | — | — | 895.11 | 706. | -0 dBm | 34 watts |

MODE OF OPERATION PL 5% 500 μsec PRI 25 μsec

| HIGH LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 118.1 | 2.6 | 307.06 | 239.8 | | |
| Ø B | 118.1 | 2.6 | 307.06 | 242.2 | | |
| Ø C | 117.6 | 2.51 | 295.18 | 229.5 | | |
| TOTAL | — | — | 909.29 | 711.5 | -0 dBm | 34 watts |

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Figure 44. (U) RF Chain Low Band, Primary Power.

PRIMARY POWER

Data Sheet 8.3.5.2. b

RF CHAIN Low Band DATE 10-8-81

Baseline CONFIGURATION

MODE OF OPERATION CW 15 msec 17 msec off

| LOW LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER watts | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 108.4 | 3.19 | 345.8 | 289.6 | | |
| Ø B | 108.6 | 3.22 | 349.67 | 295.5 | | |
| Ø C | 107.5 | 3.00 | 322.5 | 266.5 | | |
| TOTAL | — | — | 1017.97 | 851.6 | -0dBm | 54 watts |

MODE OF OPERATION CW 15 millsec PRI 17 msec off

| NOMINAL LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER watts | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 114.7 | 3.01 | 345.25 | 282.7 | | |
| Ø B | 115.45 | 3.09 | 356.74 | 296.5 | | |
| Ø C | 114.4 | 2.91 | 332.90 | 269.3 | | |
| TOTAL | — | — | 1034.89 | 848.5 | -0dBm | 51 watts |

MODE OF OPERATION CW 15 millisec PRI 17 msec off

| HIGH LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER watts | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 117.6 | 2.91 | 342.22 | 275.3 | | |
| Ø B | 118.4 | 3.02 | 357.57 | 294.6 | | |
| Ø C | 117.7 | 2.88 | 338.98 | 274.6 | | |
| TOTAL | — | — | 1038.76 | 844.5 | -0dBm | 51 watts |

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Figure 45. (U) RF Chain Low Band, Primary Power.

b. (U) Results. See figure 46 for the test setup. Only commands not exercised in the tests discussed in paragraphs 3.2.1 through 3.2.9 were exercised in this test. The results are contained in data sheet 8.3.6.1 (figure 47). The STE status response was monitored for the various commands, and indicated that the transmitter did respond properly to input commands.

3.2.11 (U) Duty Cycle Limiting

a. (U) Purpose. The purpose of the duty cycle limiting test is to demonstrate that the pulse channel monitor will limit the pulse channel output when the video command duty cycle is above the maximum specified.

b. (U) Results. The test setup is shown in figure 36. The results in figure 48 show that when the pulse generator was set to a 30 us pulse with a 6% duty cycle, the modulator did limit the auty cycle to 5.6% by decreasing the pulse width.

3.2.12 (U) BIT/ATE Output

a. (U) Purpose. The purpose of this test is to exercise and verify the built-in test capability of the rf chain LRU.

b. (U) Results. When the BIT was exercised during the response to commands testing, it indicated NO GO (see figure 47). The cause of the NO GO indication was a bad I/O board, which was giving an improper pulse width readout. After this board was replaced, the BIT test indicated that all functions of the LRU were GO. The BIT sensors and BIT test sequences included in the rf chain unit are listed in table 2.

3.3 (U) Environmental Testing

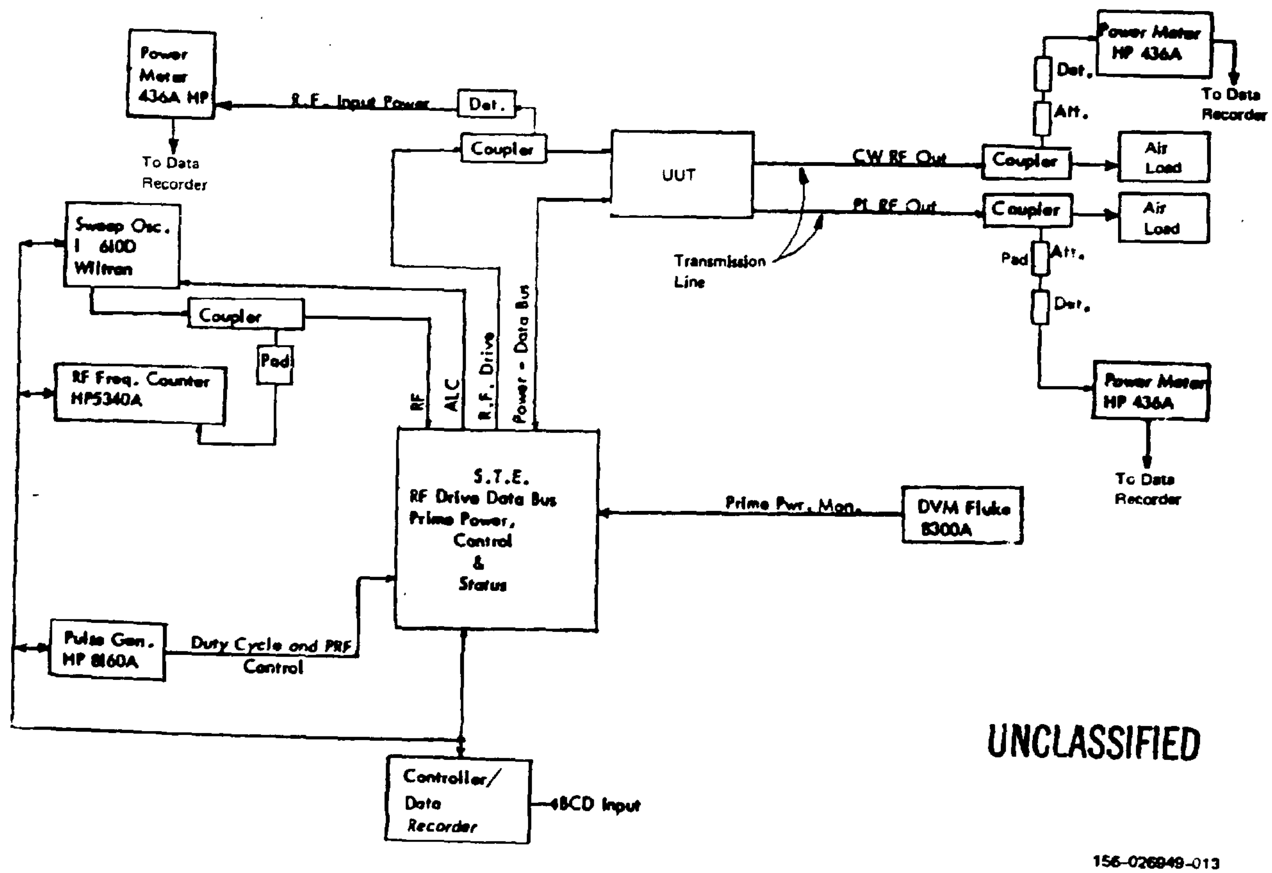


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Figure 46. (U) RF Chain Unit, Response to Commands, Logic Test Setup.

RESPONSE TO COMMANDS
Data Sheet 8.3.6.1

RF CHAIN Low Band DATE 10-8-81

Base Line CONFIGURATION

| COMMAND | STE - RESPONSE | ACTUAL |
|---|---|---|
| CW PWR OUT | 52.7 | 72% PWR METER |
| PL PWR OUT | 63.5 | 5% PWR METER |
| CW TEMP | 101 | N/A |
| PL TEMP | 101 | N/A |
| DUTY CYCLE | 4.9% | PULSE GEN 5% 25 usec / 500 usec |
| PULSE WIDTH | GO/NO GO | |
| RF INPUT | GO/NO GO | N/A |
| SELF BLANK | ~~GO/NO GO~~ WORKING | LIMIT SET AT 28 usec. |

BIT Failed: Cause - BAD I/O BOARD, INDICATED IMPROPER PULSE WIDTH

WARMUP TIME 187 seconds

156-029664-047

TEST ____________________ DATE __________

QA ____________________ DATE __________

DCAS ____________________ DATE __________

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Figure 47. (U) RF Chain Low Band, Response to Commands.

DUTY CYCLE LIMITING
Data Sheet 8.3.6.2.1

RF CHAIN Low Band DATE 10-8-91

Base Line CONFIGURATION

| | PULSE WIDTH | DUTY CYCLE |
|---|---|---|
| PULSE GENERATOR | 30 usec. /500 | 6% |
| RF OUTPUT PULSE | 28 usec. /500 | 5.6% |

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TEST ENGINEER ____ DATE ____
Q.A. ____ DATE ____
DCAS ____ DATE ____

Figure 48. (U) RF Chain Low Band, Duty Cycle Limiter.

Table 2. (U) Tests Performed by BIT.

| | Continuous BIT | Initiated BIT | Immediate Control Panel Indication | 3-Count Fault Delayed Indication | Mode Fault (Immediate Shutdown | Manual Override | Auto Restart | Common Fault Indicator Line | Digital Data Link | Latched Front Panel Fault Indicator |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. LRU Overtemperature Safety of Flight | X | | X | | X | | self | | | X |
| 2. Prime Power Phase Fault, Interlock | X | | X | | X | | self | | | X |
| 3. Excess Pulse Duty Cycle, PRF, Pulse | X | | | | | | self clear | | | X |
| 4. TWT Overtemperature | X | | X | | After 1 min. | X | self clear | | X | X |
| 5. Helix Overcurrent | X | | | X | standby | | X | X | | X |
| 6. Arc Sensors | X | | | X | standby | | X | X | | X |
| 7. HVPS Out of Regulation | X | | | X | standby | | X | X | | X |
| 8. LVPS Sensors | X | | X | | X | | self clear | X | | X |
| 9. TWT Heater | X | | | | Chan-nelized | | self clear | X | | X |
| 10. LRU RF Input | | X | | | | | | | X | |
| 11. Reflected Power | X | | | | | | | | X | |
| 12. CW Output | | X | | | | | | | X | |
| 13. Pulse Output | | X | | | | | | | X | |

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(U) The environmental tests demonstrate that the rf chain unit will operate under specified temperature and altitude extremes and under a limited vibration environment. The tests reported in this section were all performed on the low band LRU. The results of these tests can be extended to apply to the high band LRU, since the two units are of almost identical design and construction. The environmental tests performed were temperature/altitude testing and vibration testing.

3.3.1 (U) Temperature/Altitude Testing Description. After completion of the subassembly temperature/altitude testing during October and November, the rf chain LRU was tested during the time period of 14 December 1981 through 18 December 1981. The unit tested was the rf chain low band LRU in the baseline configuration. All tests listed in table 8.3.8 of the rf chain test plan (table 3) were accomplished. The test setup is shown in figure 49. All testing was conducted by R. Rutter, rf chain test engineer, and witnessed by J. Galloway, quality control representative. All tests conducted on 17 December 1981 were also witnessed by Mr. R. A. Hieber and J. Mudd of AFWAL/AAWW.

(U) The location of all test points used for the temperature/altitude testing are shown in Northrop document no. 001-00673.

3.3.2 (U) Temperature/Altitude Testing Results. All LRU testing was accomplished without failure. The only variance from the rf chain test plan occurred during altitude testing. Because of chamber limitations combined with the test setup (which pumped coolant from one chamber, through the UUT, and into the environmental chamber), the pumps used to evacuate the chamber were unable to simulate altitudes above 51,000 feet.

a. (U) Preliminary Testing. Preliminary testing in the laboratory was accomplished prior to moving the UUT to the environmental chamber. This testing was accomplished with ambient ($22^{o}C$) temperature air used as coolant. After the UUT was moved to the environmental chamber a comparison run was performed under the same conditions except that the coolant air was restricted to 3.1 pounds per minute (PPM) at a temperature of $4^{o}C$.

Table 3. (U) Standard RF Chain Low Band LRU Environmental Tests, Temperature/Altitude.

| TEST SEQUENCE NEW | TEMPERATURE | ALTITUDE | DURATION | COOLING AIR | REMARKS |
|---|---|---|---|---|---|
| 1 | Test Site Ambient | Test Site Ambient | — — | 3.1 PPM @ 4°C | Turn UUT on, record Data, Turn UUT off |
| 2 | 71°C (Cooling Baseline) | Test Site Ambient | 4 hours after UUT stabilized at +71°C chamber | 3.1 PPM @ 4°C (Note: may increase PPM) | After Chamber stabilized* at +71°C turn UUT on and record data. With UUT operating continuously, record data each hour; turn UUT off. |
| 3 | -10°C (Voltage integrity) | Test Site Ambient at -10°C chamber. (Tolerance of +0°C, -5°C) | Until UUT stabilizes | 3.1 PPM @ 4°C | When chamber stabilized*, open chamber and permit frost to form on the exterior of the UUT. Leave door open until frost melts, but not long enough for moisture to evaporate. Turn UUT on, record data, turn UUT off. |
| 4 | -40°C | Increase from ambient to high alt. (Note 1) | Until UUT stabilizes at -40°C chamber. (Tolerance of +0°C, -5°C) | 3.1 PPM @ 40°C | Turn UUT on, record data. Leave UUT on and pump chamber altitude until maximum altitude conditions are met. Record data; turn UUT off. |
| 5 | Test Site Ambient | Test Site Ambient | — — | 3.1 PPM @ 4°C | Turn UUT on, record data; turn UUT off. |

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*NOTE: STABILIZED WHEN T PER 5°C.

NOTE 1: EXISTING TEST CHAMBER CANNOT MAINTAIN 70,000 FEET AND PROVIDE ENOUGH COOLING AIR. ALTITUDES IN EXCESS OF 60,000 FEET ARE ESTIMATED.

NOTE 2: DATA FOR TEMPERATURE/ALTITUDE TEST SHALL BE RECORDED ON DATA SHEET 8.3.8.1.

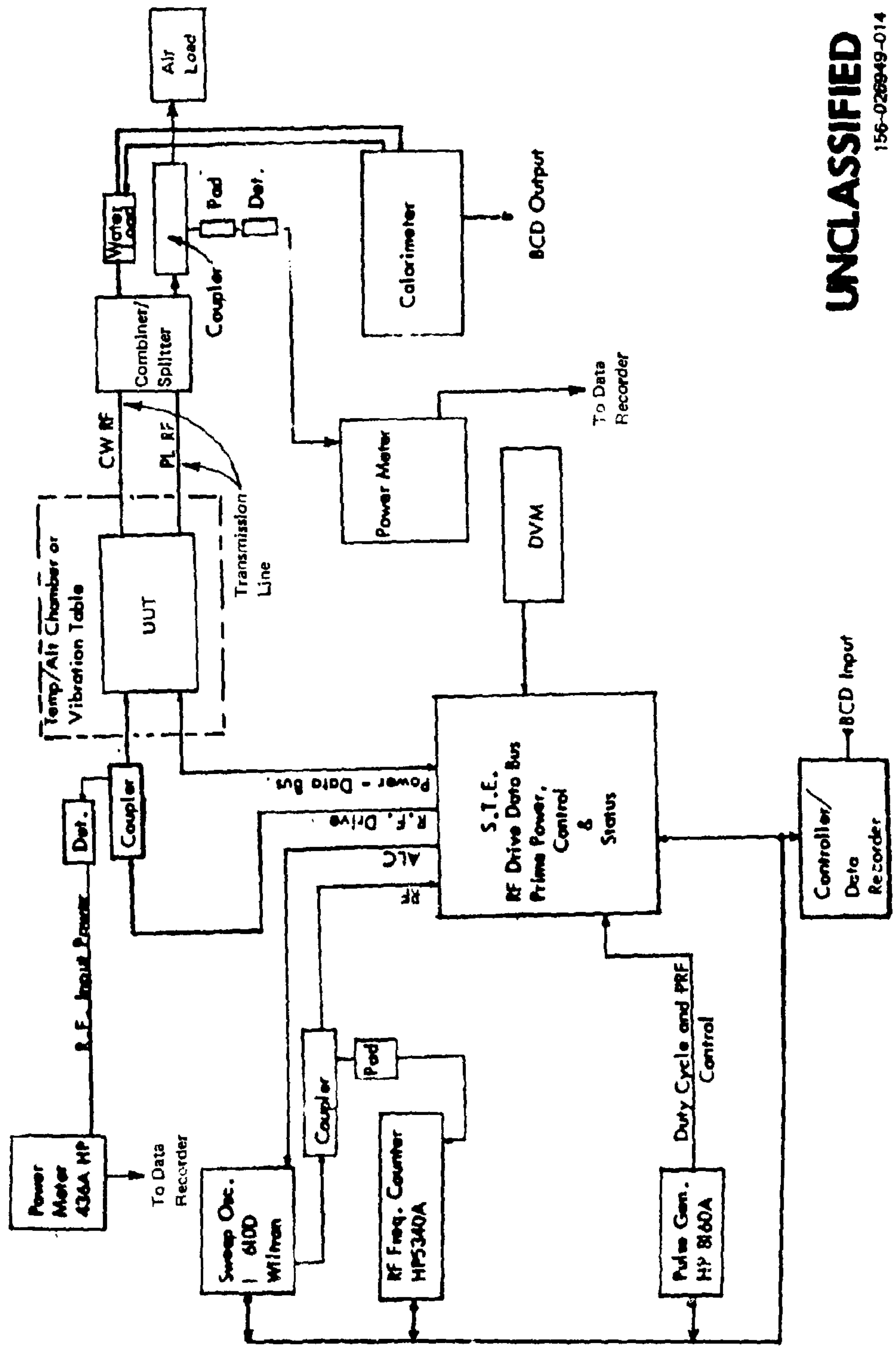



Figure 49. (U) RF Chain, Environmental Tests, Test Setup.

(U)The results of these two tests indicate that the UUT can be operated under full power output conditions using ambient room temperature air unrestricted from the coolant cart for extended periods of time without the temperatures rising beyond the safe operating temperatures of the LRU.

b. (U) Test Results. All testing was conducted in the sequence and under the conditions stated in table 8.3.8 of the rf chain test plan (table 3). Table 4 lists the highest temperatures recorded in the LRU for each of the test runs, and the CW pulse output powers. All of these tests were conducted with no failures. Comparison of Test Sequence 1 and Test Sequence 5 shows that although the UUTs temperature increased during testing, there was no significant change in its electrical performance.

3.3.3 (U) Vibration Testing Description. Vibration testing began in accordance with the Test Plan Addendum submitted to AFWAL, dated 30 November 1981. However, at 21 minutes, 20 seconds into the first test, the unit failed due to high voltage arcing which resulted in component failure internal to several hybrids. Because of the emphasis placed on containing program costs through such means as minimizing the number of spare assemblies, it was suggested to AFWAL in a letter dated 25 January 1982 that the vibration testing be discontinued. The reply from AFWAL dated 22 March 1982 approved this suggestion, and said that the vibration testing could be considered complete.

3.4 (U) Testing with the Power Share Control Module

(U) The rf chain low band LRU was used extensively in the testing of the Power Share Control Module (PSCM), Air Force contract no. F33615-81-C-1444. It was used during the baseline PSCM testing at Northrop, and then for the PSCM testing with the EDE simulator at AFWAL. The rf chain LRU operated for approximately 140 hours (17-18 days, 7 hours per day) at the EDE simulator in addition to the Northrop testing. During this time, the rf chain LRU experienced no difficulties or failures, which helps to show that the high reliability listed in the program objectives has indeed been built into this device.

Table 4. (U) Temperature/Altitude Test Results.

| TEST SEQUENCE | DURATION (HOURS) | HIGHEST TEMPERATURE RECORDED IN LRU (°C) | CW POWER OUTPUT (dBm) | PULSE POWER OUTPUT (dBm) |
|---|---|---|---|---|
| 1 | | 18.7 | 53.55 | 63.5 |
| 2 | START | 41.5 | 53.65 | 63.5 |
| 2 | 1 | 79.3 | 53.2 | 63.87 |
| 2 | 2 | 87.6 | 53.2 | 63.96 |
| 2 | 3 | 86.9 | 53.3 | 64.15 |
| 2 | 4 | 85.7 | 53.3 | 64.13 |
| 3 | | 23.6 | 53.6 | 63.8 |
| 4 | START | 9.7 | 53.67 | 63.75 |
| 4 | | 30.5 | 53.5 | 63.9 |
| 4 | | 55.5 | 53.45 | 63.5 |
| 4 | | 57.2 | 53.4 | 63.5 |
| 4 | | 62.1 | 53.4 | 63.4 |
| 4 | | 77.6 | 53.4 | 63.6 |
| 4 | | 87.7 | 53.4 | 63.6 |
| 5 | | 56.3 | 53.2 | 63.6 |

COOLING AIR: 4°C AT 3.1 PPM

INPUT RF DRIVE LEVEL: -2dBm

DUTY CYCLE: CW = 90% PULSE = 5% PULSE WIDTH = 25 us

SECRET

# SECTION IV

# HIGH BAND LRU TESTING(U)

(U) The rf chain high band LRU testing consisted of electrical performance testing with the following tubes:

a. RF Chain Baseline TWTs
b. 2% Duty Cycle DBDM TWT
c. 8% Duty Cycle Band III Pulse TWT
d. 6 dB Dual Mode TWT

(U) The high band LRU testing is intended to show that the rf chain is highly compatible with the various TWTs. Because of the great similarity in design and construction of the low band and high band units, it may be inferred that this versatility is also possessed by the low band LRU. Using the same argument, it may also be inferred that the results of the low band LRUs environmental testing apply to the high band LRU.

(U) The testing and the testing results for each TWT are described in the sections below.

## 4.1 (U) Baseline Testing

(U) The rf chain baseline testing was conducted using the baseline T-MEC TWTs originally developed for the ASPJ program. This was done to keep the rf chain program within cost and on schedule, since preliminary analysis showed that the rf chain requirements could be fulfilled by the baseline tubes. This analysis proved to be incorrect. The baseline TWTs could not be made to meet the rf chain requirements. However, the response of the rf chain when using these tubes yields baseline data about its overall performance. Since the rf chain in most cases comes close to fulfilling the rf chain requirements with the baseline tubes, it may be inferred that the rf chain would need or exceed these requirements with the appropriate TWTs.

4.1.1 (U) TWT Description: The following paragraphs list some of the specifications of the TWTs used in the rf chain high band LRU testing. The specifications and drawing for the pulse TWT are in Northrop DSD documents 093-005933 and 090-001862, respectively; and for the CW TWT, document numbers 093-005932 and 090-01861, respectively. These are some of the relevant specifications:

(S) Frequency Range: The following frequency ranges apply to both the pulse and the CW TWTs:

7.5 to 18 GHz
7.5 to 19 GHz (design goal)

(S) Rated Fundamental Power Output:

| Frequency | Power Output = CW TWT | Power Output = Pulse TWT |
|---|---|---|
| 7.5 to 8.0 GHz | +52.4 dBm | +61.8 dBm |
| 8.0 to 17.5 GHz | +53.0 dBm | +62.5 dBm |
| 17.5 to 18.0 GHz | +52.4 dBm | +61.8 dBm |
| 18.0 to 19.0 GHz (goal) | +50.0 dBm | +60.0 dBm |

(C) Maximum total power output shall not exceed 56 dBm (CW) or 66 dBm (pulse) regardless of drive level.

(C) Duty Cycle and Pulse Width: The pulse tube may be operated at continuous duty cycles up to 8% and at various pulse widths from 100 ns to 25 ns maximum, including multiple combinations thereof. The CW tube may be operated at continuous duty cycles up to 100% and at various pulse widths from CW to a minimum of 100 ns, including multiple combinations thereof.

(C) Small Signal Gain. Small signal gain for the CW TWT is 41 dB minimum, 46 dB nominal, and 51 dB maximum. Small signal gain for the pulse TWT is 51 dB minimum, 56 dB nominal, and 61 dB maximum.

(U) Noise Output: With the input port terminated in 50 ohms and the output port loaded with an attenuator, the CW TWT spurious noise output is below -13 dBm/ MHz, and the pulse TWT total integrated noise and spurious output power is below +40 dBm.

(S) At normal drive levels, the total harmonic power for each TWT is at least 3 dB below fundamental power output (-10 dBc goal). At frequencies higher than 10.5 GHz, the second harmonic is at least -15 dBc.

(C) Propagation Delay: The propagation delay for each tube does not exceed 8 ns.

4.1.2 (U) List of Tests. The baseline electrical performance tests conducted on the high band LRU are listed below:

1. Power Output vs. Frequency
2. Small Signal Gain
3. Harmonic Power
4. Spurious Outputs and Noise Power
5. TWT Transfer Characteristics
6. Mismatched Loads
7. Propagation Delay
8. Mode Switching Time
9. Primary Power
10. Response to Command
11. Duty Cycle Limiting
12. BIT/ATE Output

4.2 (U) Detailed Test Data - Baseline Testing

(U) The detailed test data for each test provided in this section is preceded by introductory paragraphs indicating the purpose, requirements, variations in test procedures (if any), a summary of the test results, and a block diagram of the test setup.

4.2.1 (U) Power Output vs. Frequency

a. (U) Purpose. The purpose of this test is to demonstrate the power output of the RF Chain High Band Amplifier across the frequency band at nominal rf input drive levels. See figure 9 for the test setup.

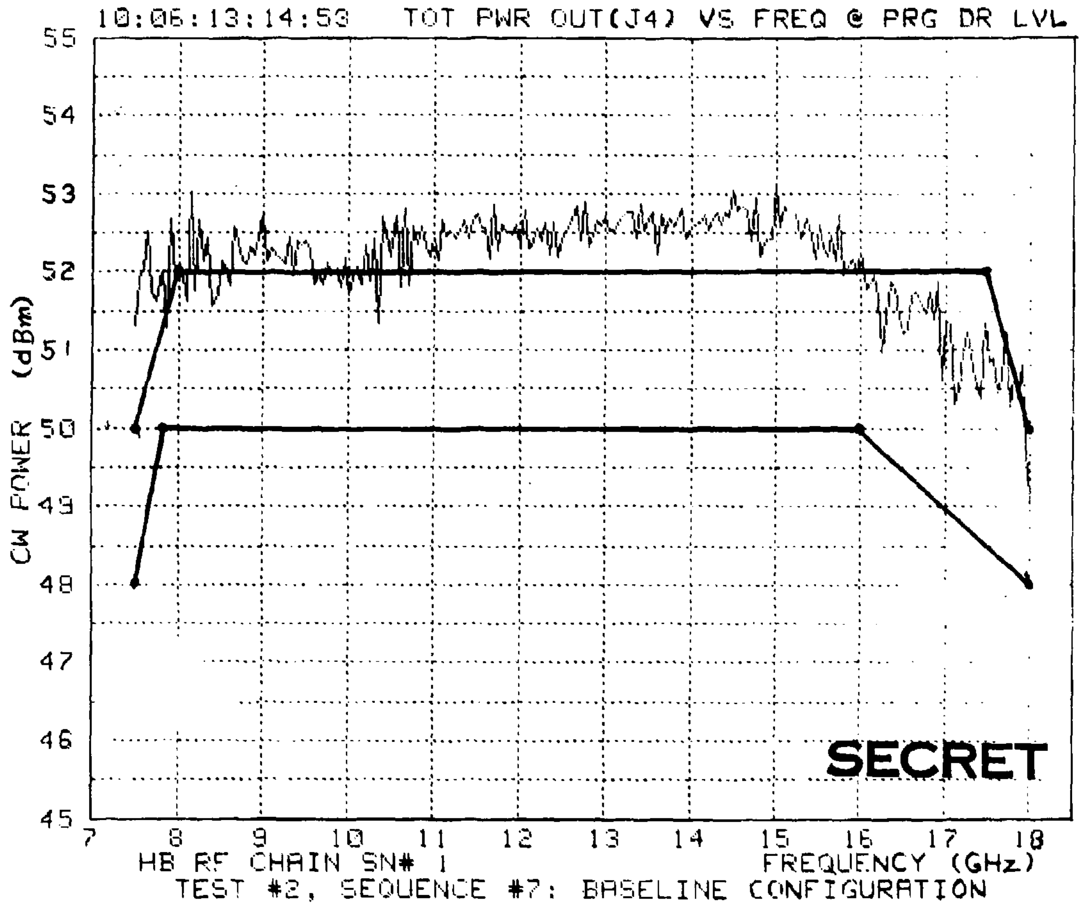
b. (U) Results. Tests were run on the CW and pulse tubes for total and fundamental power output vs. frequency, and reduced drive level power output vs. frequency. The results of these tests are shown in figures 50 through 55. The lower reference line on these graphs represents the specification to which the TWTs were built. The other reference line represents the rf chain specifications.

(U) The CW output power exceeds the specifications to which the CW tube was designed, but falls below the rf chain output power specifications in some areas of the band. The pulse output power also surpassed the tube design specification, and fell below at the rf chain specification at several points throughout the frequency band. The reduced drive level test results show that each TWT produces the same output power spectrum shape for various reduced drive levels.

4.2.2 (U) Small Signal Gain.

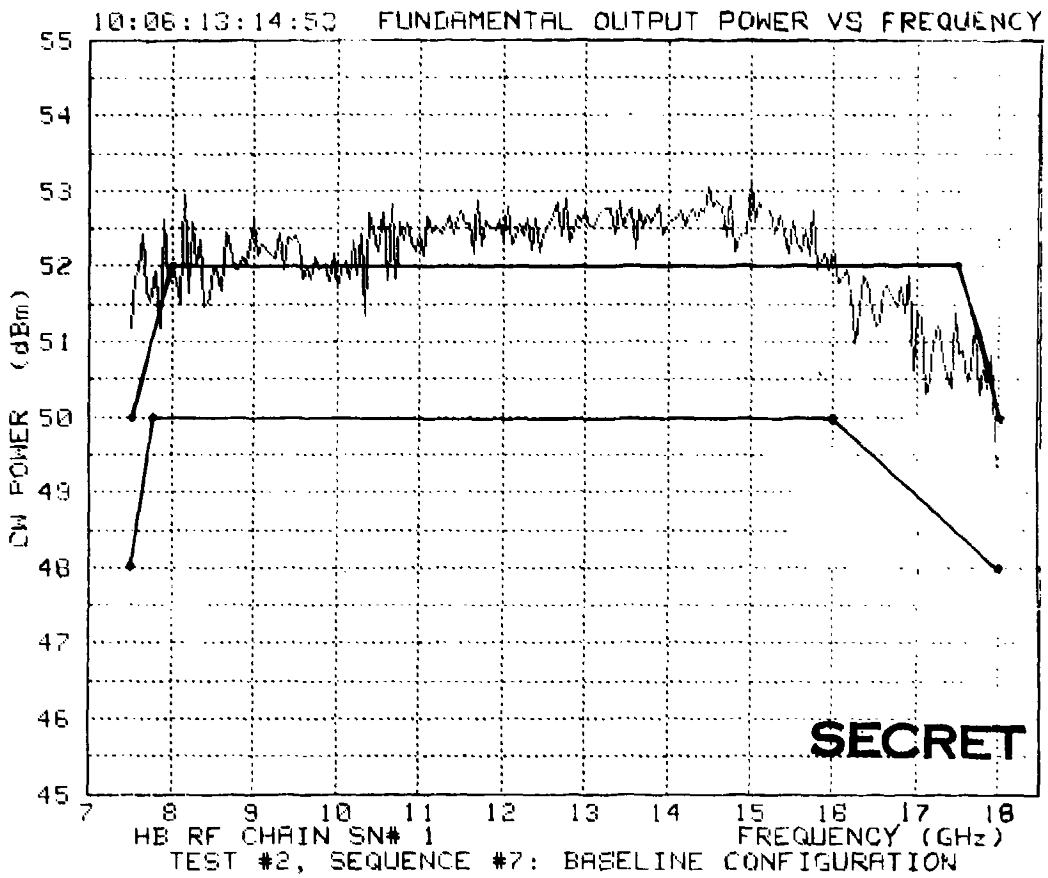
a. (U) Purpose. The purpose of this test is to demonstrate the small signal gain across the frequency band, with the rf input drive levels reduced by 15 dB from their nominal values. The test setup is shown in figure 9.

b. (S) Results The tests were run with the input drive level 15 dB down from its nominal value. The results of this test are shown in figures 56 and 57. Here again the unit did not meet rf chain specifications (67 dB minimum for CW, 77 dB for pulse), but exceeded the tube design specification (41 dB minimum for CW, 51 dB for pulse).



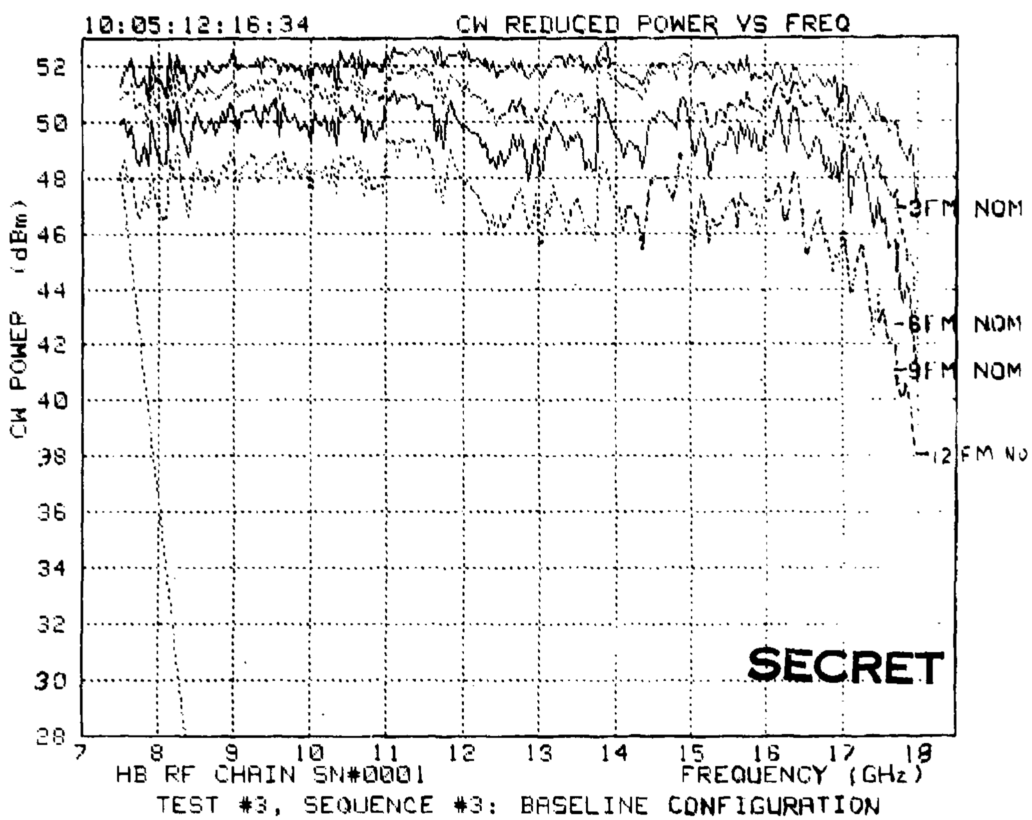

166-029664-050

Figure 50. (U) RF Chain High Band, CW Total Power Output vs. Frequency, CW = 100%.



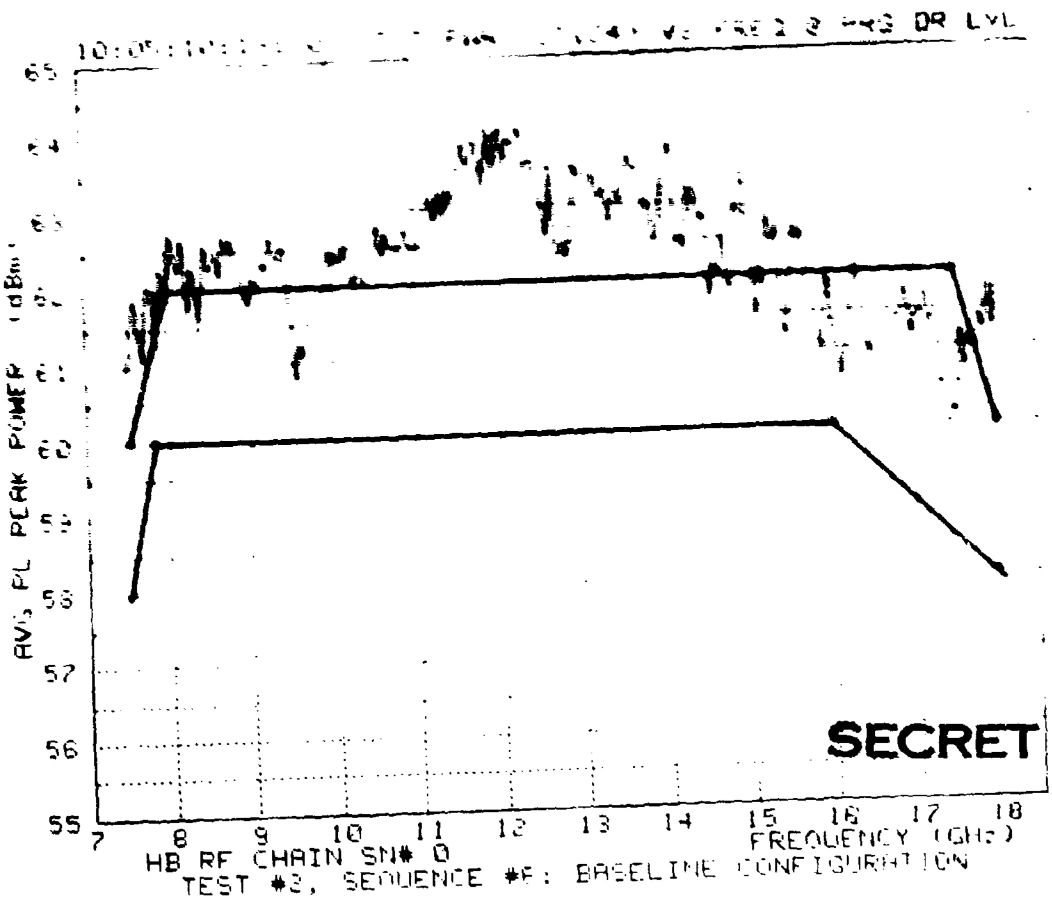

156-029864-051

Figure 51. (U) RF Chain High Band, CW Fundamental Output Power vs. Frequency, CW = 100%.



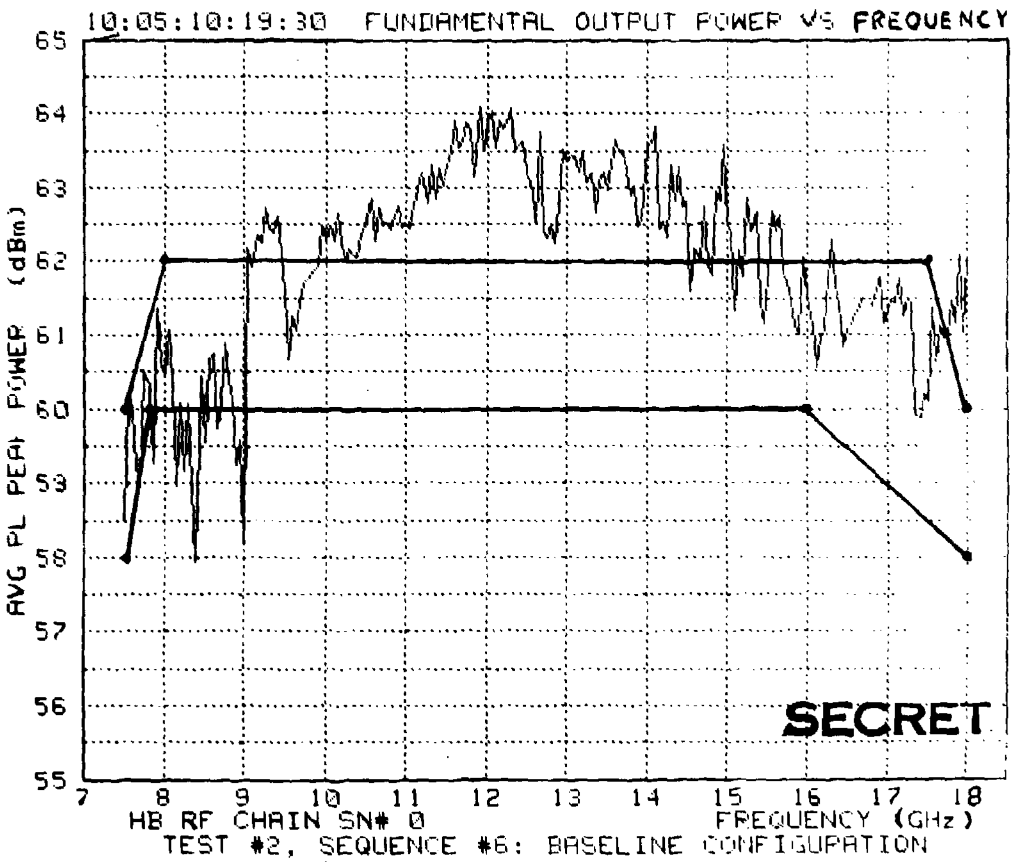

158-029664-052

Figure 52. (U) RF Chain High Band, CW Reduced Power vs. Frequency, CW = 100%.




158-029864-053

Figure 53. (S) RF Chain High Band, PLS Total Power Output vs. Frequency, PLS = 25 us at 5%.




156-029864-054

Figure 54. (S) RF Chain High Band, PLS Fundamental Output Power vs. Frequency, PLS = 25 us at 5%.

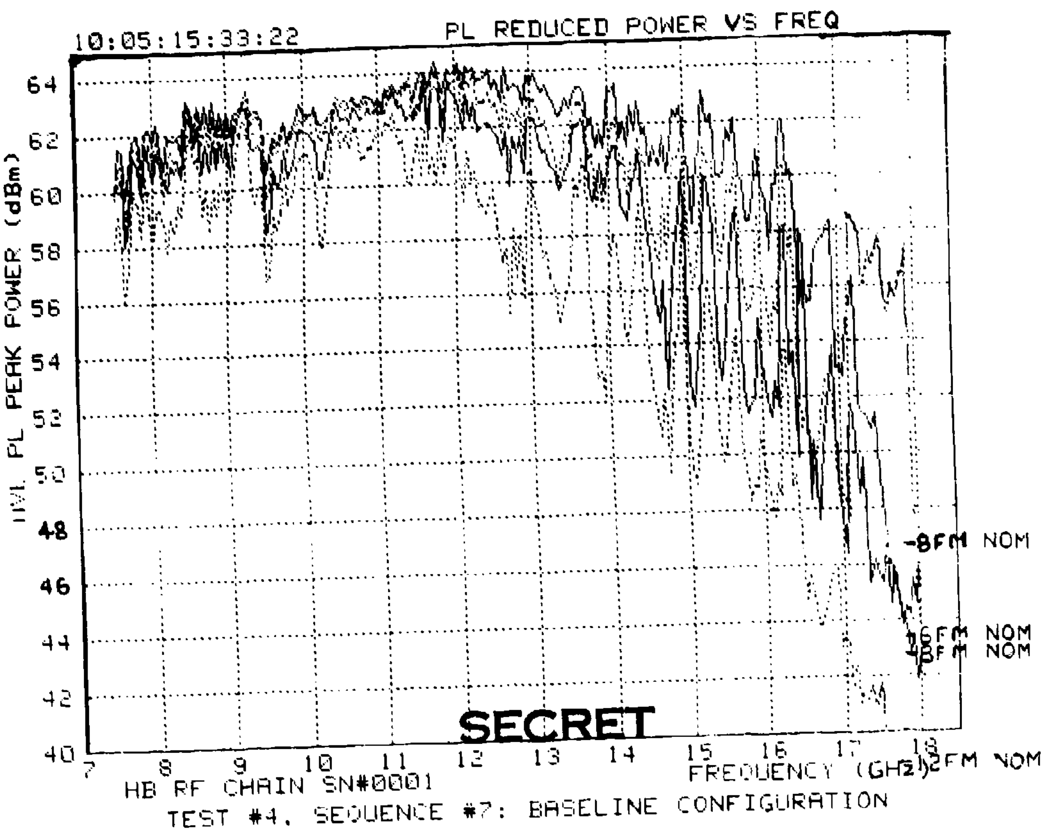



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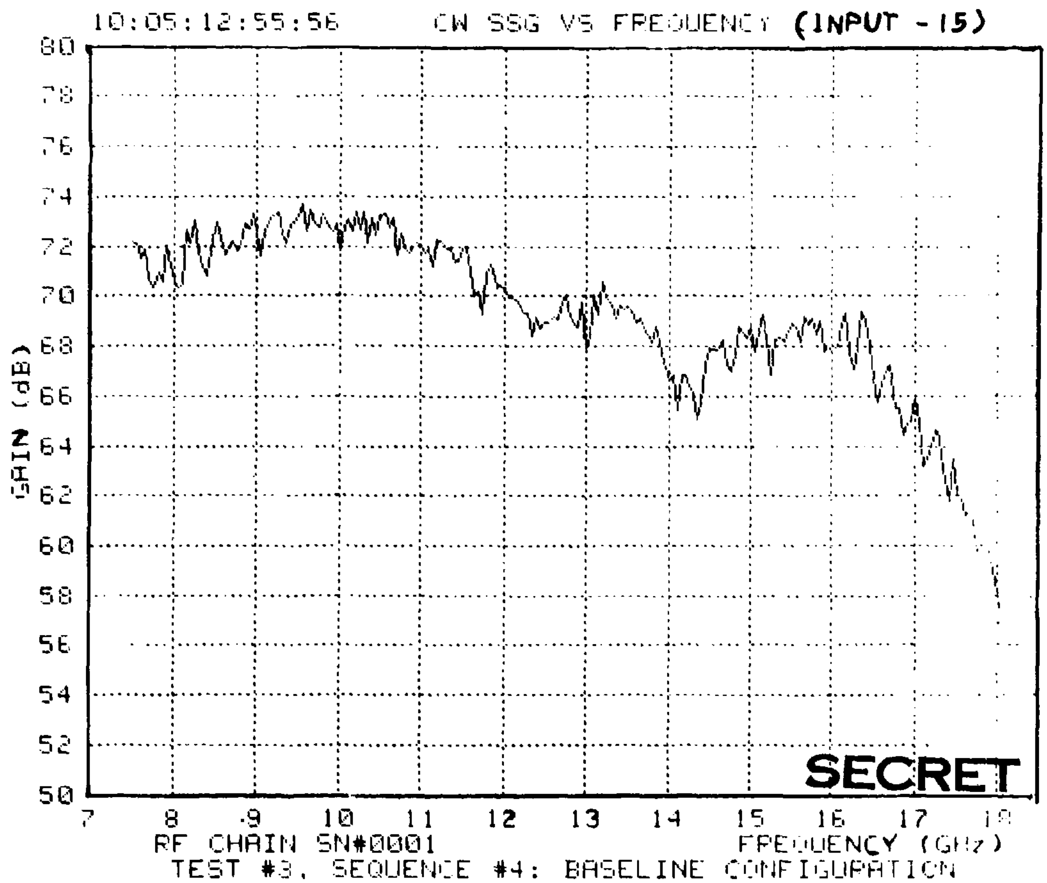
Figure 55. (S) RF Chain High Band, PLS Reduced Power vs. Frequency, PLS = 25 us at 5%.




156-029864-066

Figure 56. (U) RF Chain High Band, CW Small Signal Gain vs Frequency, CW = 100%.

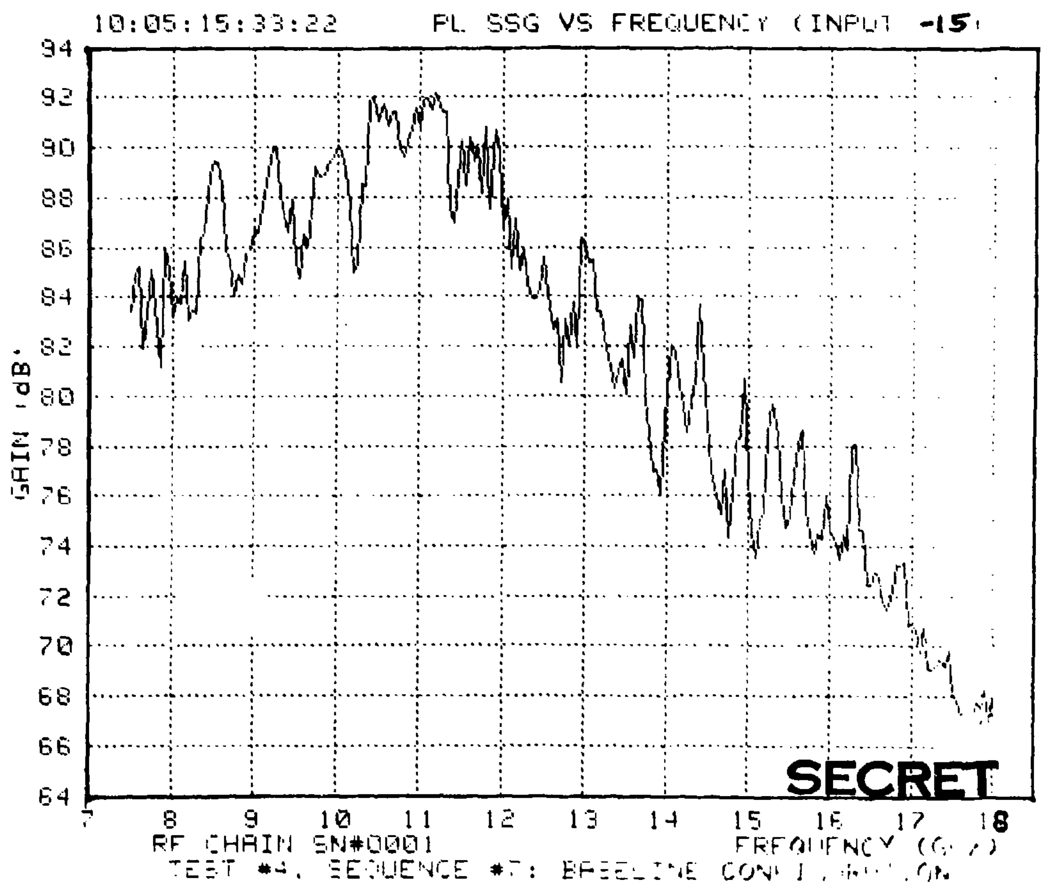



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Figure 57. (S) RF Chain High Band, CW Small Signal Gain vs. Frequency, PLS = 25 us at 5%.

4.2.3 (U) Harmonic Power

a. (U) Purpose. This test measured the relationship between the total output power and the harmonic power for harmonic outputs within the calibration frequency range.

b. (S) Results. This test was performed concurrently with the tests described in paragraph 4.2.1 (see figure 9). The results are shown in figures 58 and 59. The worst case harmonic power in the CW mode was -13 dBc at 8.8 GHz, which fulfills the rf chain requirements of a worst case second harmonic of -3 to -4 dBc. The worst case harmonic power for the pulse tube was 2.75 dBc at 8.2 GHz. This is total harmonic power. The rf chain requires the typical second harmonic to be -10 dBc.

4.2.4 (U) Spurious Outputs and Noise Power

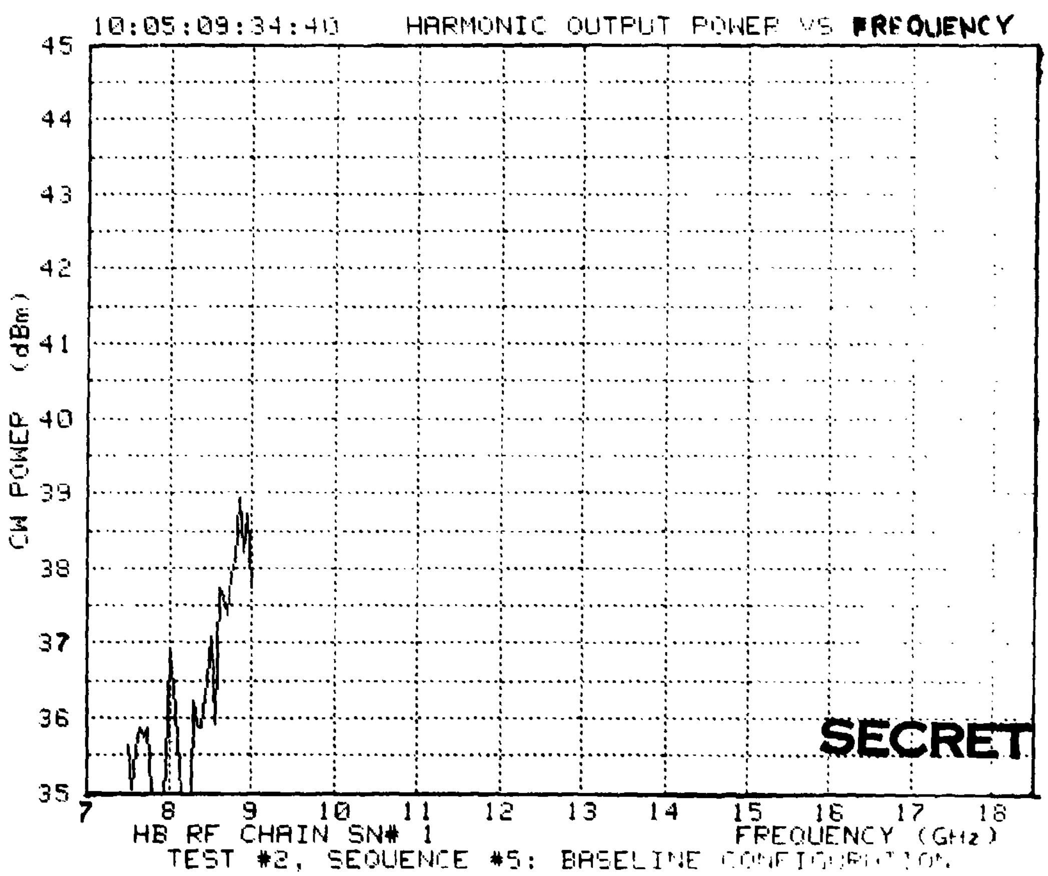
a. (U) Purpose. The purpose of this test is to demonstrate that the UUT meets the spurious noise output requirements. The test setup is shown in figure 20.

b. (C) Results. This test is conducted in accordance with paragraph 8.3.2.2 of the rf chain test plan. The results are shown in data sheet 8.3.2 figure 60. The requirements are -3 dBm/MHz maximum for CW and 40 dBm maximum for pulse. No spurious outputs exceeded specification.

4.2.5 (U) TWT Transfer Characteristics.

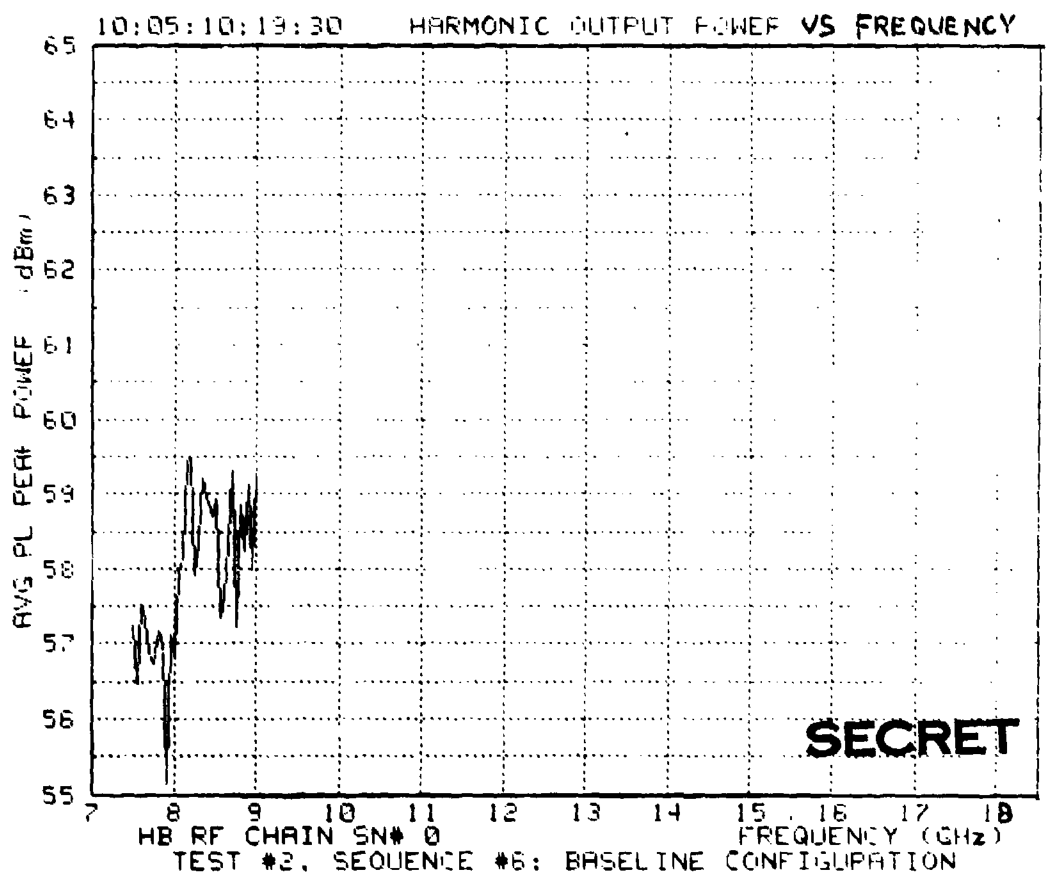
a. (U) Purpose. The purpose of this test is to show the relationship between the rf input drive into the rf chain LRU and the output power of the LRU. This information is supplied as supplemental information to required test data.

b. (U) Results. The test configuration is shown in figure 9. The test results are shown in figures 61 through 66. The CW tube shows very linear results up to its saturation point. The transfer characteristics of the pulse tube are not nearly as linear at the programmed test frequencies.




156-029894-068

Figure 58. (U) RF Chain High Band, CW Harmonic Output Power vs. Frequency, CW = 100%.




186-020004-060

Figure 59. (S) RF Chain High Band, PLS Harmonic Output Power vs. Frequency, PLS = 25 us at 5%.

RF CHAIN High Band DATE 10-9-81

Baseline CONFIGURATION

| | BLANK | CW | PL |
|---|---|---|---|
| LOW BAND EDGE | -72 dB | -64 dB | -72 dB |
| MID BAND | -62 dB | -59 dB | -62 dB |
| HIGH BAND EDGE | -60 dB | -60 dB | -60 dB |

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TEST ENGINEER ____ DATE ____

Q.A. ____ DATE ____

DCAS ____ DATE ____

Figure 60. U) RF Chain High Band, Spurious Outputs.

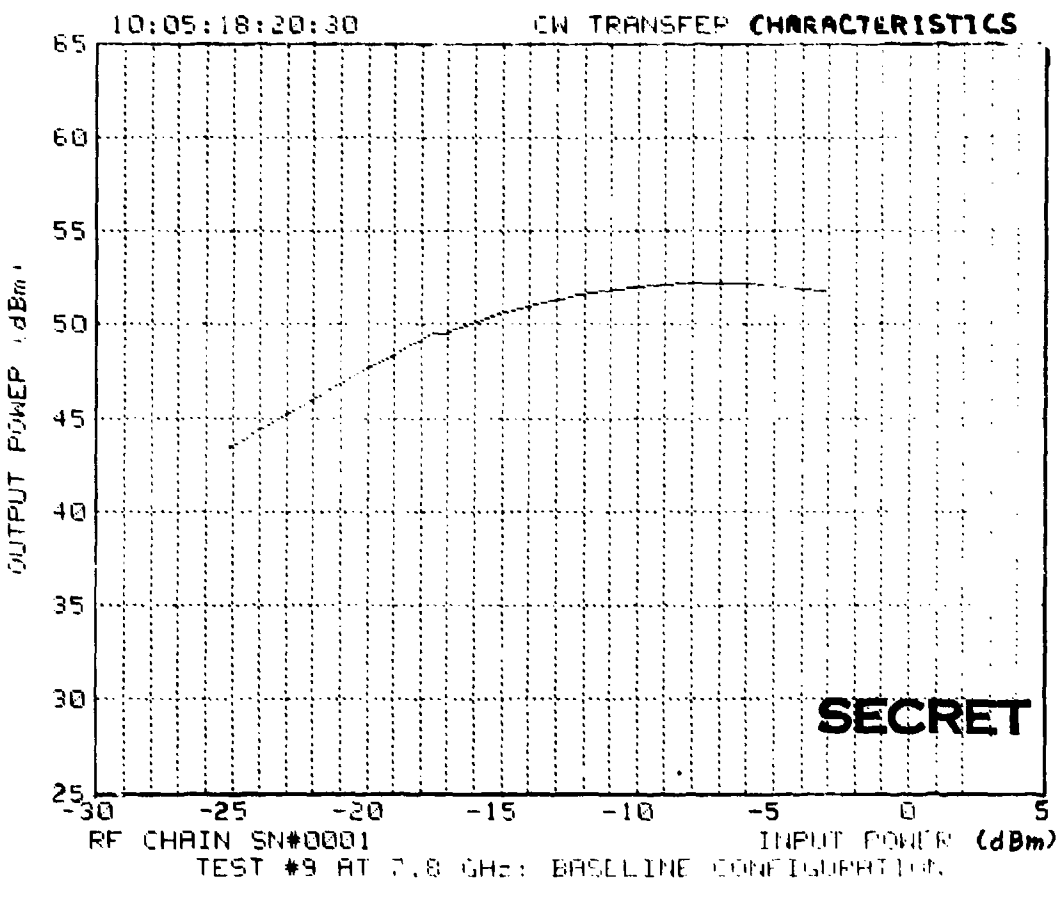
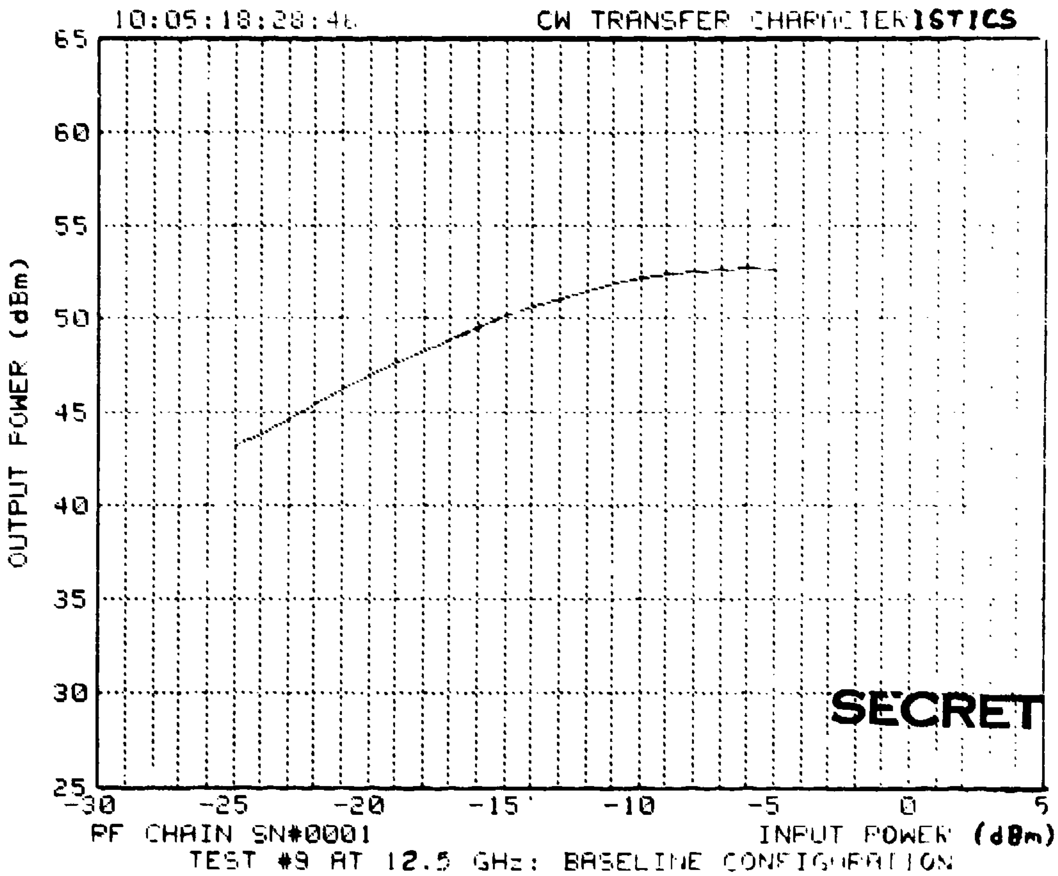



Figure 61. (U) RF Chain High Band, CW Transfer Characteristics at 7.8 GHz, CW = 100%.




158-029664-082

Figure 62. (U) RF Chain High Band, CW Transfer Characteristics at 12.5 GHz, CW = 100%.

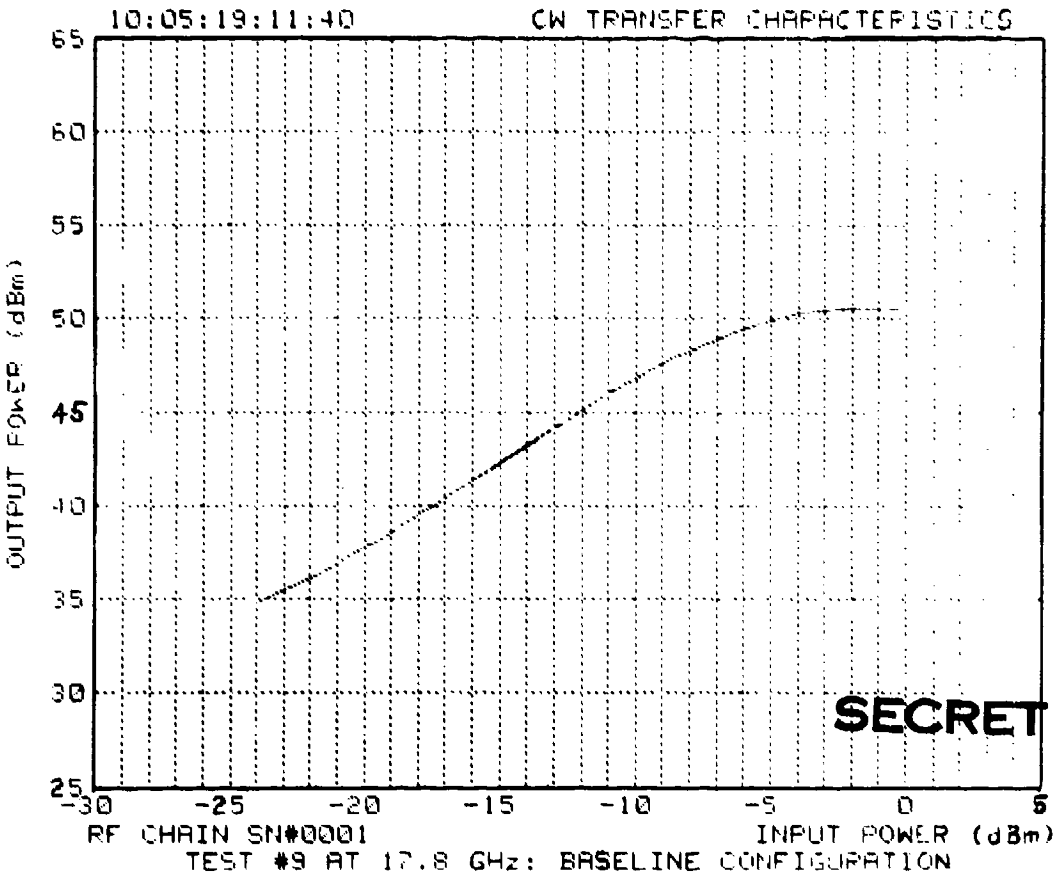
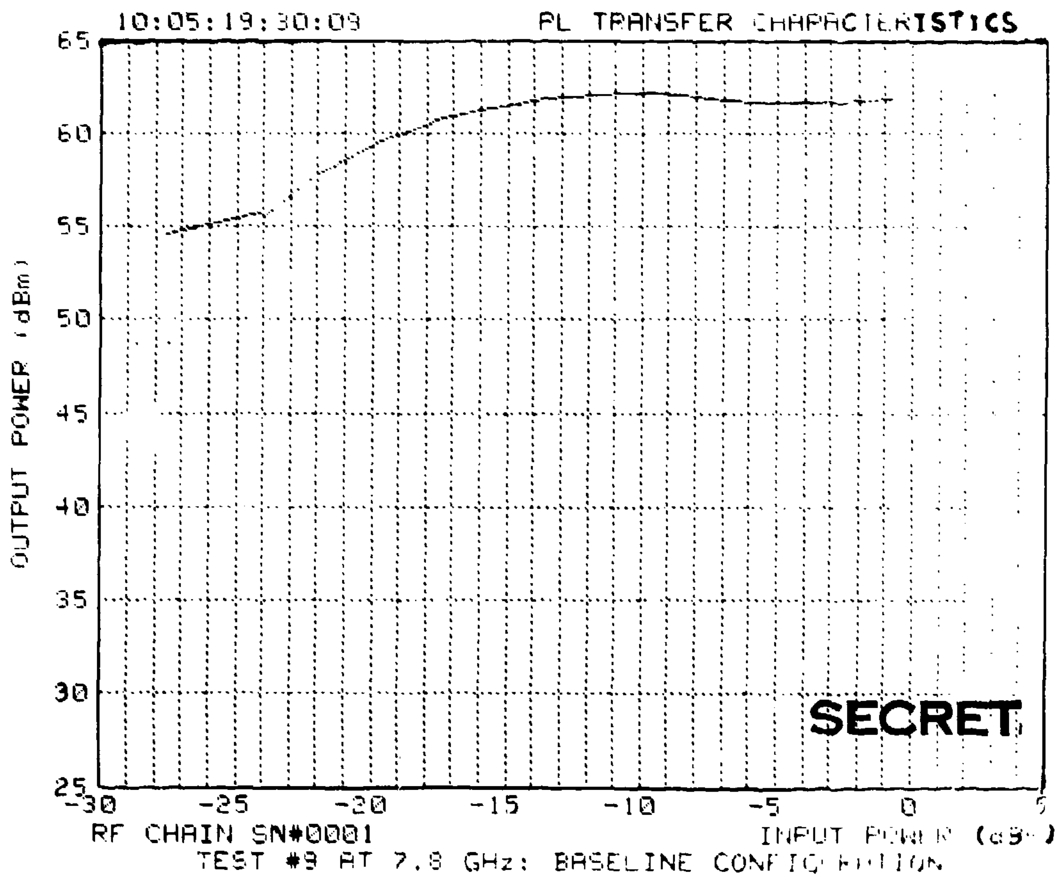



Figure 63. (U) RF Chain High Band, CW Transfer Characteristics at 17.8 GHz, CW = 100%.




156-029664-094

Figure 64. (S) RF Chain High Band, PLS Transfer Characteristics at 7.8 GHz, PLS = 25 us at 5%.

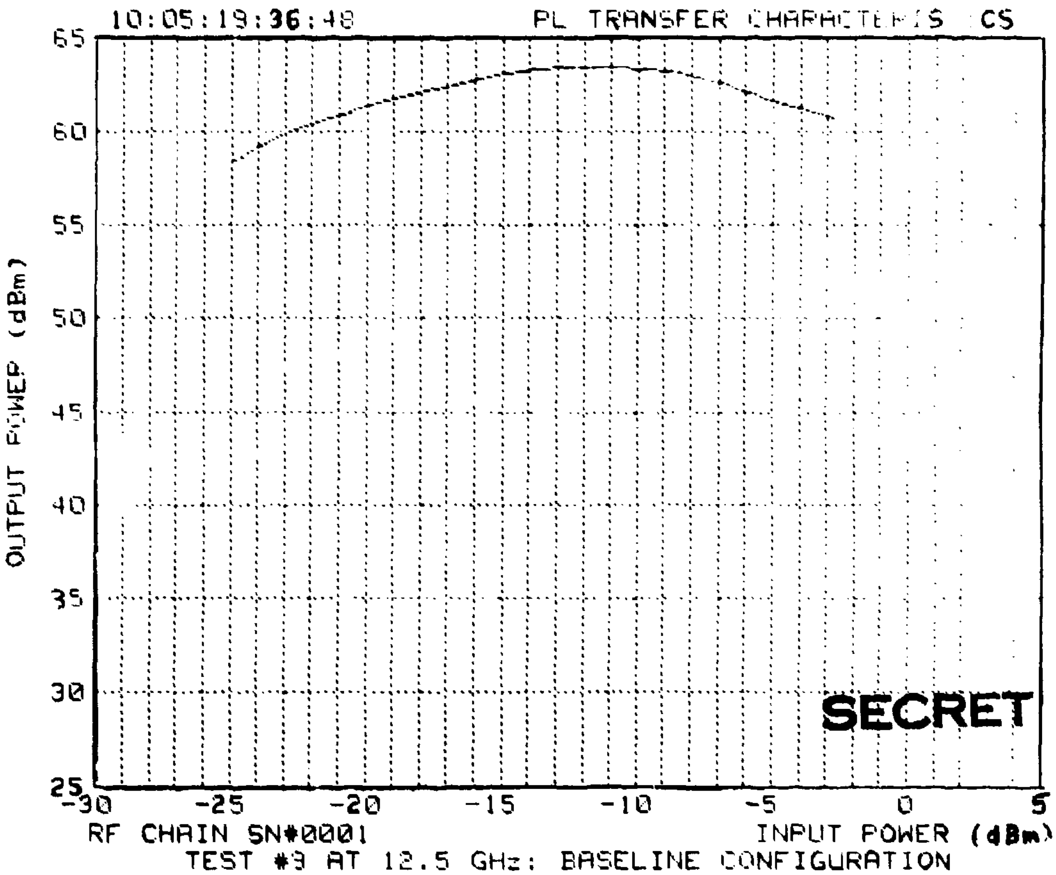
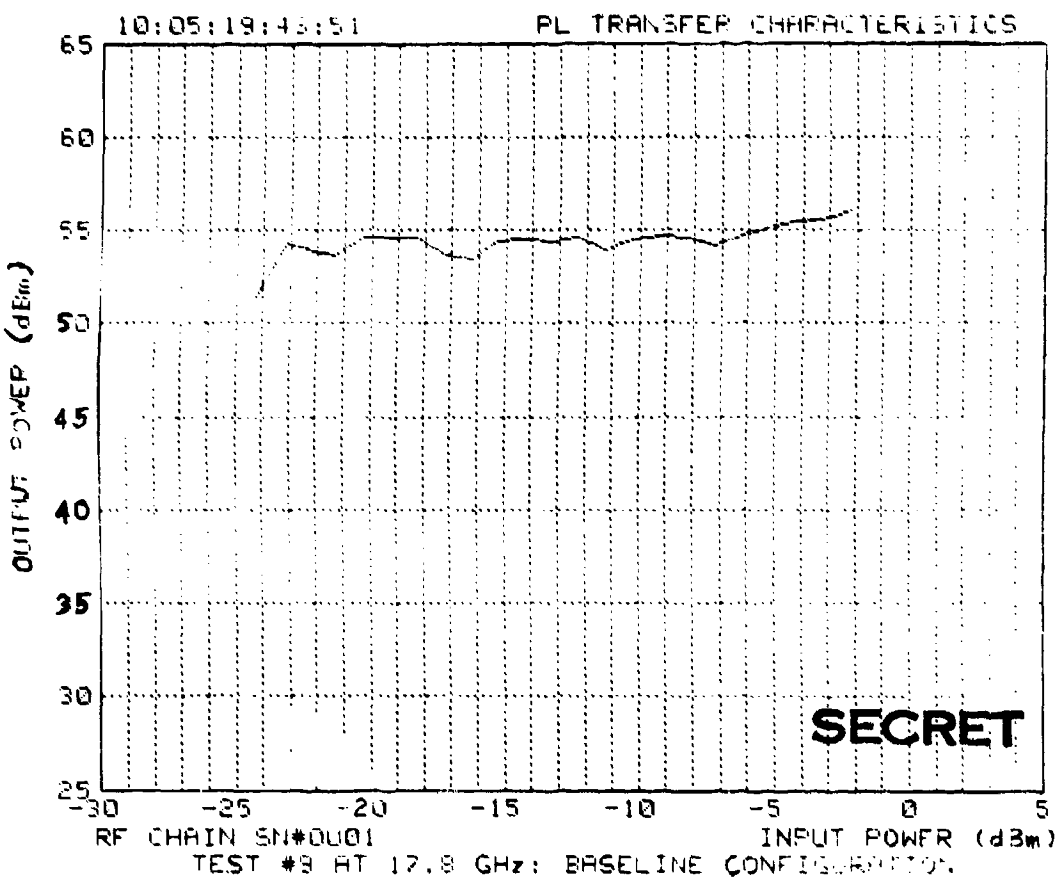



Figure 65. (S) RF Chain High Band, PLS Transfer Characteristics at 12.5 GHz, PLS = 25 us at 5%.




186-029864-086

Figure 66. (S) RF Chain High Band, PLS Transfer Characteristics at 17.8 GHz, PLS = 25 us at 5%.

4.2.6 (U) Mismatched Loads.

a. (U) Purpose. This test was performed to determine the effect on rf chain power output of operating into a load that presents a less than optimum impedance match. The test setup is shown in figure 30.

b. (C) Results. The rf chain is required to operate into loads with a VSWR of 2:1. The test was performed with a 2:1 mismatch of random phase to simulate a worst case feed line and antenna loading condition. The test results are shown in figures 67 and 68. The CW output power showed a maximum decrease of 0.69 dB and the pulse showed a maximum decrease of 29.22 dB.

4.2.7 (U) Propagation Delay. The propagation delay test was not accomplished with the high band LRU because of non-availability of high speed test equipment. Since the low band LRU performed satisfactorily during this test, and because of the identical construction of the high band and low band LRUs, no problems are foreseen in regard to the high band LRUs propagation time.

4.2.8 (U) Mode Switching Time

a. (U) Purpose. The objective of the mode switching time test is to measure the response of the UUT during different combinations of timing sequences for CW, pulse, and blank modes. The test setup is shown in figure 36.

b. (U) Variations in Procedure. A single pulse generator setup for double pulse output was used instead of the two pulse generator setups called for in table 1 of the rf chain test plan (shown in figure 37).

10:06:13:14:53 HB RF CHAIN SN#1

TEST #7, SEQUENCE #7: BASELINE CONFIGURATION

RESULTS OF MATCHED LOADS CW

| FREQUENCY (GHz) | OUTPUT POWER (dBm) |
|---|---|
| 7.8 | 52.31 |
| 12.5 | 52.89 |
| 17.5 | 51.07 |

RESULTS OF MISMATCHED LOADS CW

| FREQUENCY (GHz) | OUTPUT POWER (dBm) |
|---|---|
| 7.8 | 52.88 |
| 12.5 | 53.16 |
| 17.5 | 50.38 |

156-029064-067

SECRET

Figure 67. (U) RF Chain High Band, Mismatched Loads.

10:06:13:14:53 HB RF CHAIN SN#1

TEST #7, SEQUENCE #7: BASELINE CONFIGURATION

RESULTS OF MATCHED LOADS PL

| FREQUENCY (GHz) | OUTPUT POWER (dBm) |
|---|---|
| 7.8 | 61.84 |
| 12.5 | 62.97 |
| 17.8 | 46.06 |

RESULTS OF MISMATCHED LOADS PL

| FREQUENCY (GHz) | OUTPUT POWER (dBm) |
|---|---|
| 7.8 | 61.35 |
| 12.5 | 33.75 |
| 17.8 | 46.35 |

156-029664-068

SECRET

Figure 68. (U) RF Chain High Band, Mismatched Loads.

c. (U) Results. The mode switching time test was performed in the CW and pulse modes of operation. The pulse generator was programmed for double pulse output, and the pulse separation was adjusted to the point at which the detected rf output pulse separation was at a minimum (see data sheet 8.3.4.1, figure 69). A mode switching time of 75-100 ns is required. The results in figure 70 show a mode switching time of about 150 ns.

### 4.2.9 (U) Primary Power

a. (U) Purpose. The objective of the primary power test is to measure the warmup time of the UUT and to determine the input power requirements at high line, low line, and nominal input voltage settings. Additionally, this test will verify the prorated warmup time after a primary power interrupt.

b. (U) Results. The test setup is shown in figure 40. The warmup time was measured to 214 seconds. The prorated warmup time was 2 seconds of warmup time for each second of interrupt time for up to 90 seconds of interrupt time. After 90 seconds of primary power interrupt time, the full warmup time is required.

(U) The primary power requirement is a three phase, 400 Hz supply at 115 V ±5%. The maximum input power specified is 800 watts per tube. The results (figures 71 through 74) show that the minimum primary power is always maintained; and while the CW tube sometimes exceeds 800 watts, the pulse tube never does, and the total power requirements never exceed 1600 watts for both tubes.

### 4.2.10 (U) Response to Commands.

a. (U) Purpose. The purpose of this test is to verify that the UUT operates in all modes, responds to digital commands, and that it generates and processes proper status information whenever status is requested.

RF CHAIN High Band DATE 10-9-81

Baseline CONFIGURATION

| MODE OF OPERATION | PULSE WIDTH | DBL | SEPARATION |
|---|---|---|---|
| PC | 100 nsec | 794 nsec | 694 nsec |
| CW | 100 nsec | 795 nsec | 695 nsec |

CONFIDENTIAL

156-029664-059

TEST ENGINEER ______________________ DATE ________

Q.A. ______________________ DATE ________

DCAS ______________________ DATE ________

Figure 69. (U) RF Chain High Band, Minimum Pulse Separation.

PL MINIMUM PULSE SEPARATION

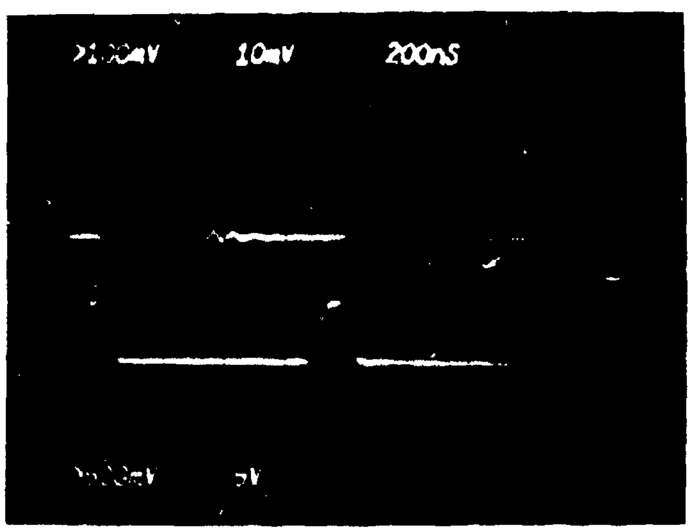

DETECTED RF
OUTPUT (INVERTED)

PL MODULATOR
COMMANDS

156-029664-070X

**CONFIDENTIAL**

CW MINIMUM PULSE SEPARATION




DETECTED RF
OUTPUT

CW MODULATOR
COMMANDS

156-029664-070

**CONFIDENTIAL**

Figure 70. (U) RF Chain High Band, Mode Switching Time.

PRIMARY POWER

Data Sheet 8.3.5.2.a

RF CHAIN High Band DATE 12-9-81

Baseline CONFIGURATION

MODE OF OPERATION ST'BY

| LOW LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 108.4 | 1.01 | 109.48 | 46.32 | | |
| Ø B | 109.2 | 1.03 | 112.48 | 52.26 | | |
| Ø C | 108.4 | .97 | 105.15 | 47.11 | | |
| TOTAL | — | — | 327.108 | 145.69 | -0- | -0- |

MODE OF OPERATION ST'BY

| NOMINAL LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 114.3 | 1.02 | 116.59 | 44.5 | | |
| Ø B | 115 | 1.05 | 120.75 | 51.62 | | |
| Ø C | 114.3 | .99 | 113.16 | 46.22 | | |
| TOTAL | — | — | 350.49 | 142.34 | -0- | -0- |

MODE OF OPERATION ST'BY

| HIGH LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 118.6 | 1.05 | 124.53 | 44.7 | | |
| Ø B | 119.4 | 1.09 | 130.15 | 52.61 | | |
| Ø C | 118.7 | 1.01 | 119.89 | 46.70 | | |
| TOTAL | — | — | 374.56 | 144.01 | -0- | -0- |

156-029864-071

UNCLASSIFIED

Figure 71. (U) RF Chain High Band, Primary Power.

PRIMARY POWER

Data Sheet 8.3.5.2. b

RF CHAIN High Band DATE 10-9-81

Base Line CONFIGURATION

MODE OF OPERATION CW 100%

| LOW LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| ø A | 108 | 3.24 | 349.92 | 295.7 | | |
| ø B | 108.2 | 3.3 | 357.06 | 303.5 | | |
| ø C | 107.6 | 3.16 | 340.02 | 287 | | |
| TOTAL | — | — | 1046.99 | 886.2 | -6.86 | 8.38 |

MODE OF OPERATION CW 100% P.F. +40'

| NOMINAL LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| ø A | 114.8 | 3.15 | 361.62 | 299.9 | | |
| ø B | 114.8 | 3.14 | 360.47 | 297.9 | | |
| ø C | 114.0 | 3.03 | 345.42 | 284.5 | | |
| TOTAL | — | — | 1067.51 | 882.3 | -6.89 | 8.34 |

MODE OF OPERATION CW 100%

| HIGH LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| ø A | 117.7 | 3.1 | 364.87 | 298 | | |
| ø B | 118.0 | 3.18 | 375.24 | 310 | | |
| ø C | 117.0 | 2.92 | 341.64 | 274.5 | | |
| TOTAL | — | — | 1081.75 | 882.5 | -6.9 | 8.34 |

156-029664-072

UNCLASSIFIED

Figure 72. (U) RF Chain High Band, Primary Power.

PRIMARY POWER

Data Sheet 8.3.5.2.c

RF CHAIN High Band DATE 10-9-81

Baseline CONFIGURATION

MODE OF OPERATION PL 5% 25 μsec PW 300 μsec PRI

| LOW LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 107.3 | 2.92 | 313.32 | 258.7 | | |
| Ø B | 107.5 | 3.00 | 322.5 | 269.3 | | |
| Ø C | 107.2 | 2.87 | 307.66 | 254.5 | | |
| TOTAL | — | — | 943.48 | 782.5 | -6.86 | +5.60 |

MODE OF OPERATION PL 5% P.F. +35°

| NOMINAL LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 114.4 | 2.88 | 329.472 | 267.5 | | |
| Ø B | 114.3 | 2.86 | 326.898 | 265.4 | | |
| Ø C | 113.9 | 2.76 | 314.364 | 252.9 | | |
| TOTAL | — | — | 970.734 | 785.8 | -6.86 | +4.93 |

MODE OF OPERATION PL 5%

| HIGH LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 117.4 | 2.85 | 334.59 | 266.4 | | |
| Ø B | 117.7 | 2.9 | 341.33 | 276.9 | | |
| Ø C | 116.5 | 2.67 | 311.06 | 242.7 | | |
| TOTAL | — | — | 986.975 | 786. | -6.83 | +4.22 |

158-029664-07?

UNCLASSIFIED

Figure 73. (U) RF Chain High Band, Primary Power.

PRIMARY POWER

Data Sheet 8.3.5.2.d

RF CHAIN High Band DATE 10-9-81

Baseline CONFIGURATION

MODE OF OPERATION PC + CW P.F. +64°

| LOW LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 106.4 | 5.05 | 537.32 | 482.6 | | |
| Ø B | 106.7 | 5.11 | 545.24 | 491.9 | | |
| Ø C | 106.3 | 5.01 | 532.563 | 478.7 | | |
| TOTAL | — | — | 1615.123 | 1453.2 | -6.86 | +9.91 |

MODE OF OPERATION PC + CW PL = 24μsec OFF 3μsec, CW 470μsec OFF 3

| NOMINAL LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 114.1 | 4.74 | ~~603.054~~ [illegible] | 476.6 | | |
| Ø B | 114.5 | 4.92 | 563.34 | 500.6 | | |
| Ø C | 114.0 | 4.76 | 542.64 | 479.2 | | |
| TOTAL | — | — | 1696.8 | 1456.4 | -6.86 | +10.24 |

MODE OF OPERATION PC + CW P.F. + 67°

| HIGH LINE | INPUT VOLTAGE | INPUT CURRENT | INPUT V-A | INPUT POWER | INPUT Rf dBm | OUTPUT Rf dBm |
|---|---|---|---|---|---|---|
| Ø A | 117.0 | 4.71 | 551.07 | 484.4 | | |
| Ø B | 117.2 | 4.80 | 562.56 | 496.5 | | |
| Ø C | 116.5 | 4.64 | 540.56 | 475.2 | | |
| TOTAL | — | — | 1654.19 | 1456.1 | -6.86 | +10.25 |

158-028684-074

UNCLASSIFIED

Figure 74. (U) RF Chain High Band, Primary Power.

b. (U) Results. See figure 46 for the test setup. Only commands not exercised in the tests discussed in paragraphs 4.2.1 through 4.2.9 were exercised in this test. The results are contained in data sheet 8.3.6.1 (figure 75). The STE status response was monitored for the various commands, and indicated that the transmitter did respond properly to input commands.

4.2.11 (U) Duty Cycle Limiting.

a. (U) Purpose. The purpose of the duty cycle limiting test is to demonstrate that the pulse channel monitor will limit the pulse channel output when the video command duty cycle is above the maximum specified.

b. (U) Results. The test setup is shown in figure 36. The results in figure 76 show that when the pulse generator was set to a 30 us pulse with a 6% duty cycle, the modulator did limit the duty cycle to 5.2% by decreasing the pulse width.

4.2.12 (U) BIT/ATE Output.

a. (U) Purpose. The purpose of this test is to exercise and verify the built-in test capability of the rf chain LRU.

b. (U) Results. When the BIT was exercised during the response to commands testing, it indicated that all functions of the LRU were GO. This is indicated on data sheet 8.3.6.1 (figure 75).

4.3 (U) Testing with the 2% Duty Cycle DBDM TWT

(U) To show the versatility of the standard rf chain, the high band LRU was tested with a DBDM TWT. This tube was able to achieve only a 2% duty cycle, but that is sufficient to show the DBDM capability of the RF Chain Power Amplifier.

RESPONSE TO COMMANDS

Data Sheet 8.3.6.1

RF CHAIN High Band DATE 10-9-81

Baseline CONFIGURATION

| COMMAND | RESPONSE | ACTUAL |
|---|---|---|
| CW PWR OUT | 52.2 | PWR METER 2.37 |
| PL PWR OUT | 62.2 | PWR METER 3.38 |
| CW TEMP | 102 | |
| PL TEMP | 102 | |
| DUTY CYCLE | 4.9% | PULSE GEN 5% 25 µsec / [illegible] |
| PULSE WIDTH | GO/NO GO | |
| RF INPUT | GO/NO GO | |
| SELF BLANK | ~~GO/NO GO~~ Works | Limit Set At 26 µsec |

BIT Go 3 times in row

WARMUP TIME 214 sec.

TEST ______ DATE ______

QA ______ DATE ______

DCAS ______ DATE ______

UNCLASSIFIED 156-429864-076

Figure 75. (U) RF Chain High Band, Response to Commands.

DUTY CYCLE LIMITING
Data Sheet 8.3.6.2.1

RF CHAIN High Band DATE 10-9-81

Baseline CONFIGURATION

| | PULSE WIDTH | DUTY CYCLE |
|---|---|---|
| PULSE GENERATOR | 30 μsec/500 μsec | 6% |
| RF OUTPUT PULSE | 26 μsec/500 μsec | 5.2% |

UNCLASSIFIED

TEST ENGINEER ________ DATE ________
Q.A. ________ DATE ________
DCAS ________ DATE ________

156-029664-076

Figure 76. (U) RF Chain High Band, Duty Cycle Limiting.

4.3.1 (U) 2% DBDM Description. The following paragraphs list some of the specifications of the 2% DBDM TWT. The tube drawing and specifications are contained in Northrop DSD documents 090-001875 and 093-006152, respectively. These are some of the relevant specifications.

(S) Frequency Range: This TWT amplifies rf signals within the frequency range of 10.4 GHz to 18.0 GHz.

(S) Rated Fundamental Output Power: The minimum output power of this TWT is:

| Frequency | CW Mode | Pulse Mode |
|---|---|---|
| 13.0 GHz | 200 watts | 2000 watts |
| 10.4 to 16.5 GHz | 155 watts | 1550 watts |
| 16.5 to 18.0 GHz | 145 watts | 1450 watts |

(C) Duty Cycle: The maximum pulse duty cycle for this TWT is 10%; the maximum pulse duration is 30 us.

(U) Small Signal Gain: The CW small signal gain is in the range of 42 dB to 52 dB; for the pulse mode, the range for small signal gain is 55 dB to 65 dB.

(U) Noise Output: The noise output power is no greater than -10 dBm/MHz in the CW mode and no greater than +3 dBm/MHz peak in the pulse mode.

(U) At normal drive levels, the harmonic signal level is down to a minimum of 10 dB from the fundamental rf output power.

(U) Propagation Delay: The rf delay from the TWT amplifier assembly input to the output does not exceed 8.0 ns.

(U) TWT Difficulties: When this TWT was built, it did not meet many of these specifications. For example, its duty cycle is only 2%, and its small signal gain and maximum power output are below those specified. RF chain testing will be done on another DBDM tube when one becomes available. These specifications were included to illustrate some of the difficulties being experienced in procuring usable TWTs for testing - this is the reason why the standard rf chain program is behind the original schedules.

(U) Even though this TWT did not meet specifications, it still functions as a DBDM TWT, and is completely adequate to show the RF Chain DBDM TWT capabilities.

4.3.2 (U) List of Tests. The electrical performance tests conducted on the rf chain high band LRU with the 2% duty cycle DBDM TWT are listed below:

1. Small Signal Gain
2. CW Power Output
3. Pulse Power Output
4. CW and Pulse Power Output

## 4.4 (U) Detailed Test Data - 2% DBDM TWT

(U) The detailed test data for each test provided in this section is preceded by introductory paragraphs indicating the purpose of each test, and a summary of the test results.

(U) This testing was conducted to show the compatibility of the standard rf chain with DBDM tubes. Therefore, only those tests which show this compatibility were performed.

### 4.4.1 (U) Small Signal Gain.

a. (U) Purpose. The purpose of these tests is to demonstrate the small signal gain across the frequency band, with the rf input drive levels reduced from their nominal values. See figure 9 for the test setup.

b. (U) Results. The rf input drive levels were reduced from their nominal values by 12 dB for the test results shown in figures 77 and 78 (CW and pulse SSG, respectively). Figures 79 and 80 show the results for tests run at various reduced drive levels (3 dB, 6 dB, 9 dB and 12 dB below rated input). These results show that the rf chain can use either mode of the DBDM independently, and produce a nearly level small gain curve across the tube's frequency band.

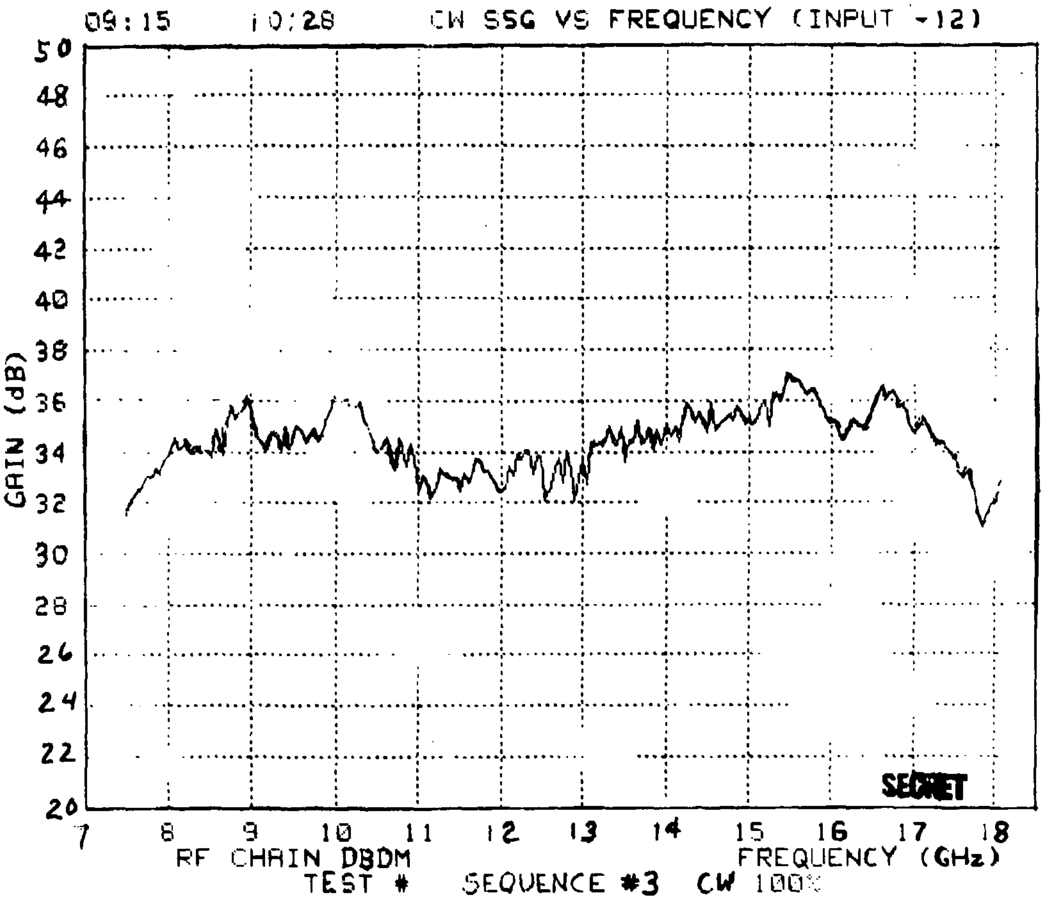
4.4.2 (U) CW Power Output

a. (U) Purpose. The purpose of these tests is to show the rf chain unit's power output, in the CW mode only. The test setup is shown in figure 9.

b. (U) Results. Figure 81 shows the CW output power across the frequency bands. This looks fairly level, except where the output power drops at the high end of the band. Figure 82 shows the detected rf output response to the CW modulator commands. The delay is not visible at this time division setting (5 us/div.). Figures 83 through 85 show the CW transfer characteristics at low, middle and high band frequencies. In each case, the transfer characteristic curves are very linear.

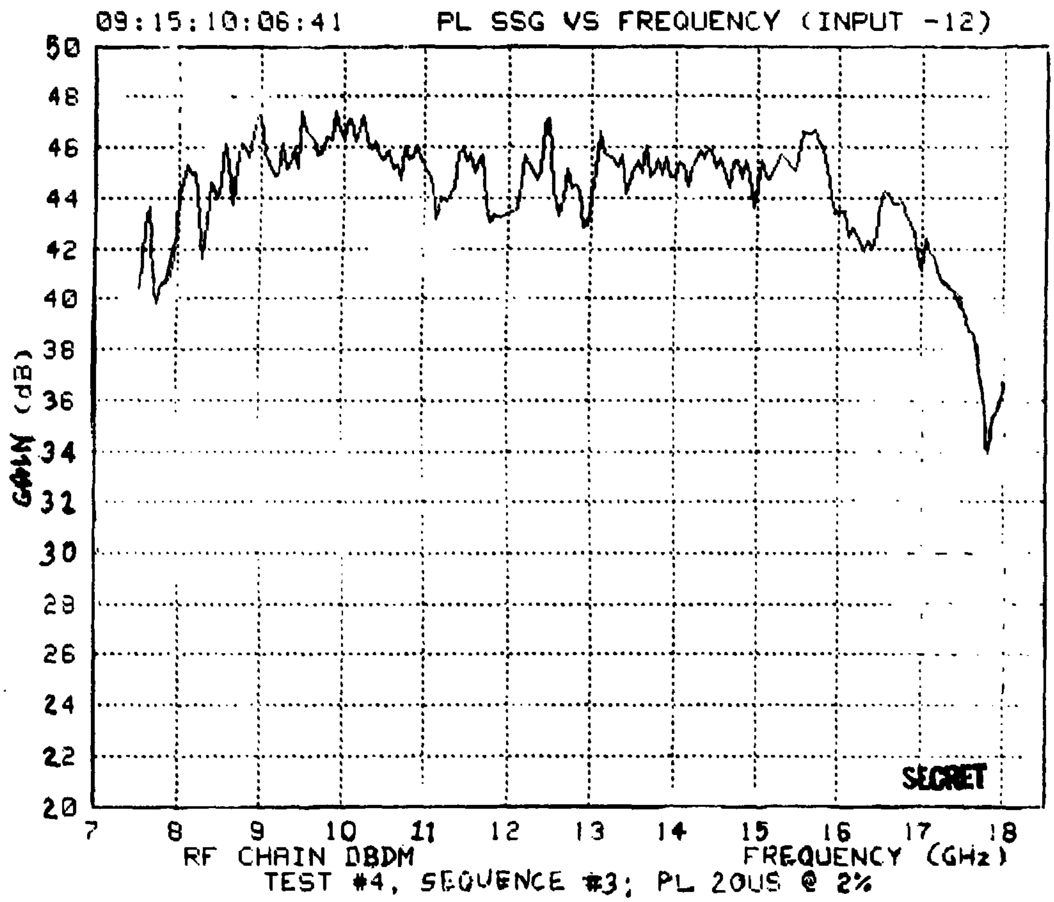
4.4.3 (U) Pulse Power Output.

a. (U) Purpose. The purpose of this test is to show the rf chain units' power output, in the pulse mode only. The test setup is given in figure 9.



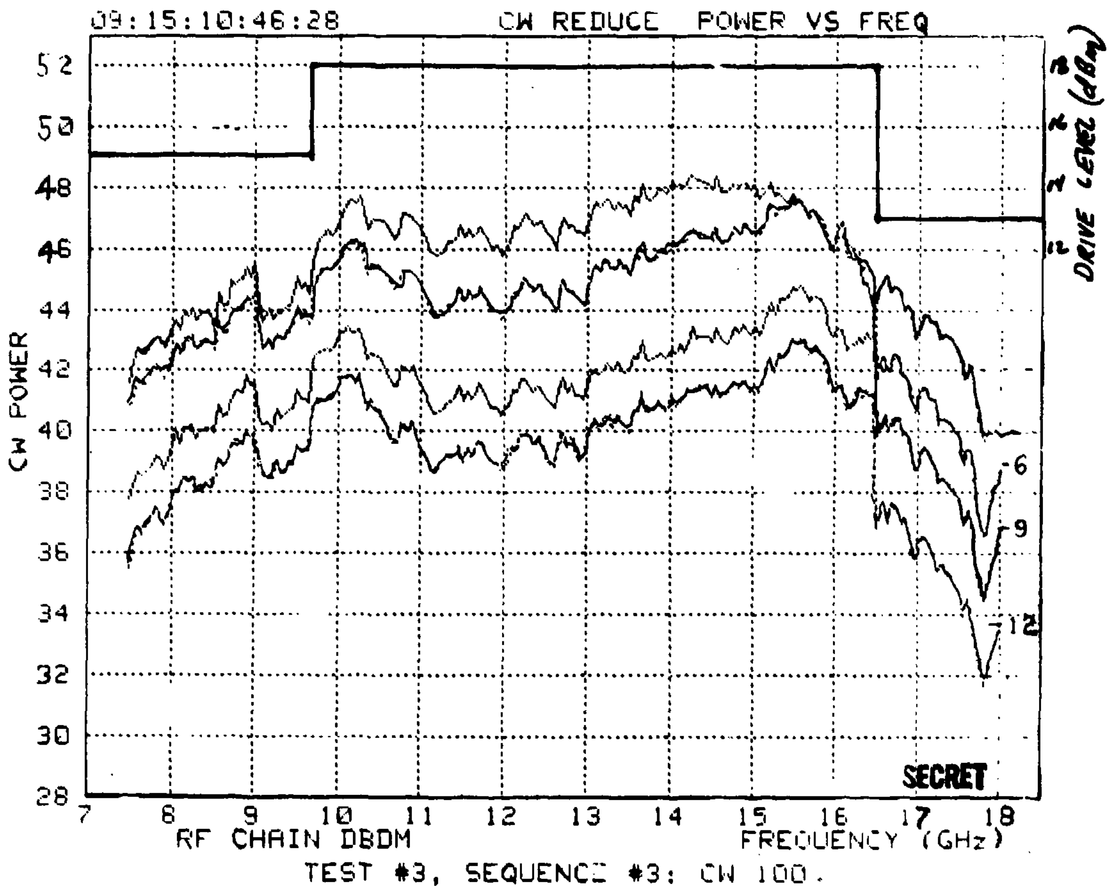

156-029664-077

Figure 77. (U) RF Chain DBDM Test No. 3, Sequence 3: CW SSG vs. Frequency, CW = 100%.



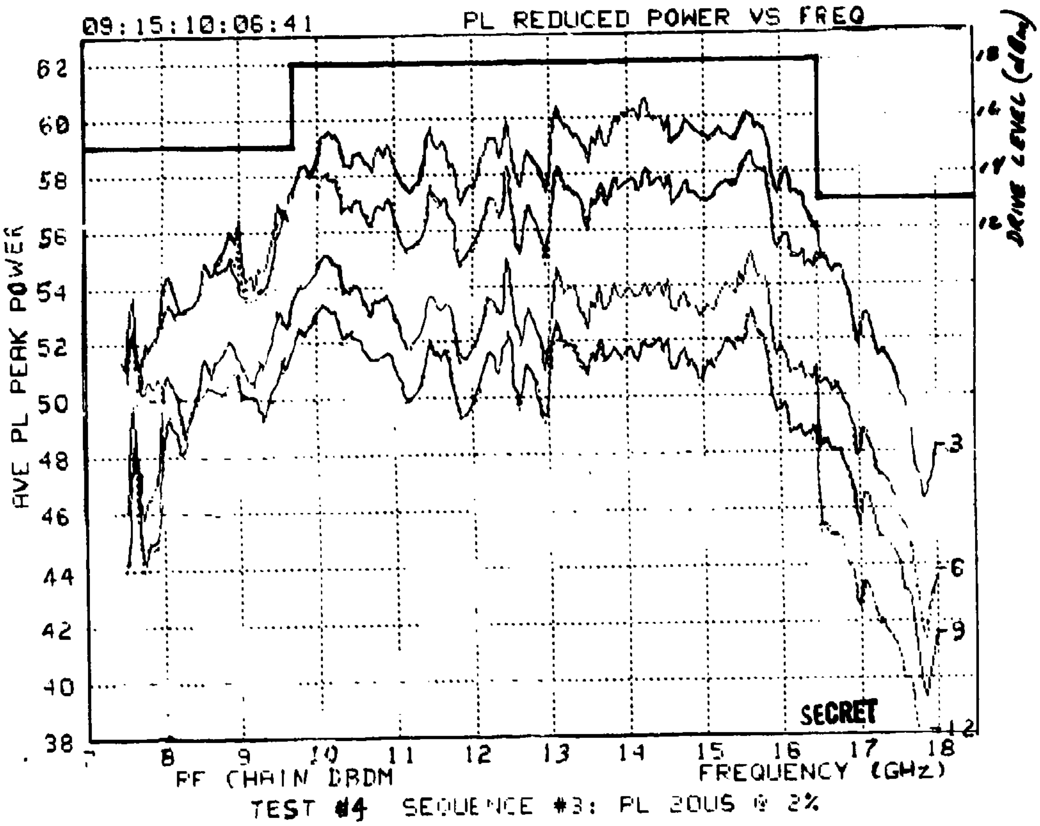

150-029084-078

Figure 78. (S) RF Chain DBDM Test No. 4, Sequence No. 3: PLS SSG vs Frequency, PLS = 20 us at 2%.



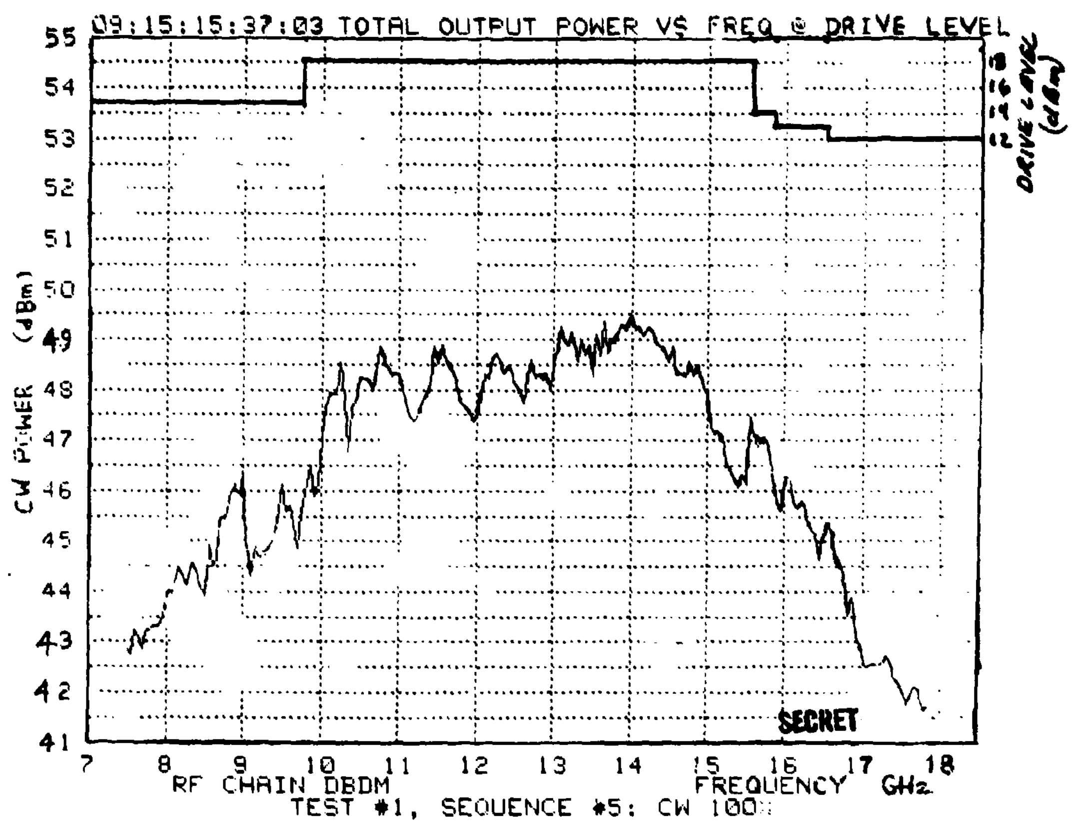

156-029664-079

Figure 79. (U) RF Chain DBDM Test No. 3 Sequence No. 3: CW Reduced Power vs. Frequency, CW = 100%.




156-029664-080

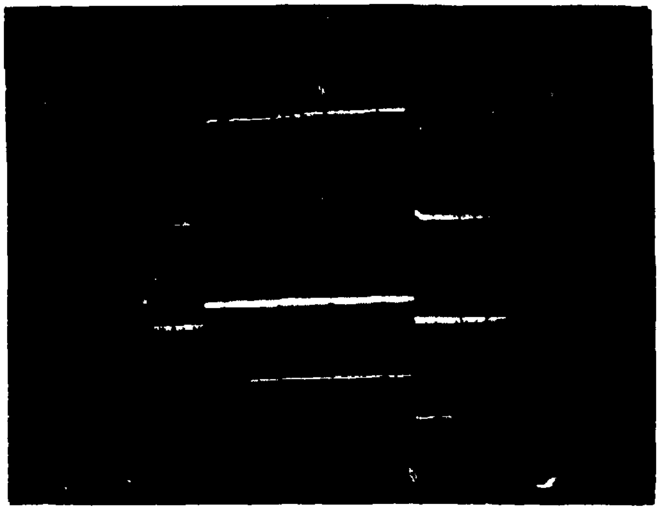
Figure 80. (S) RF Chain DBDM Test No. 4, Sequence No. 3: PLS Reduced Power vs. Frequency, PLS = 20 us at 2%.




158-029664-081

Figure 81. (U) RF Chain DBDM Test No. 1, Sequence No. 5: Total Power Output vs. Frequency at Drive Level, CW = 100%.

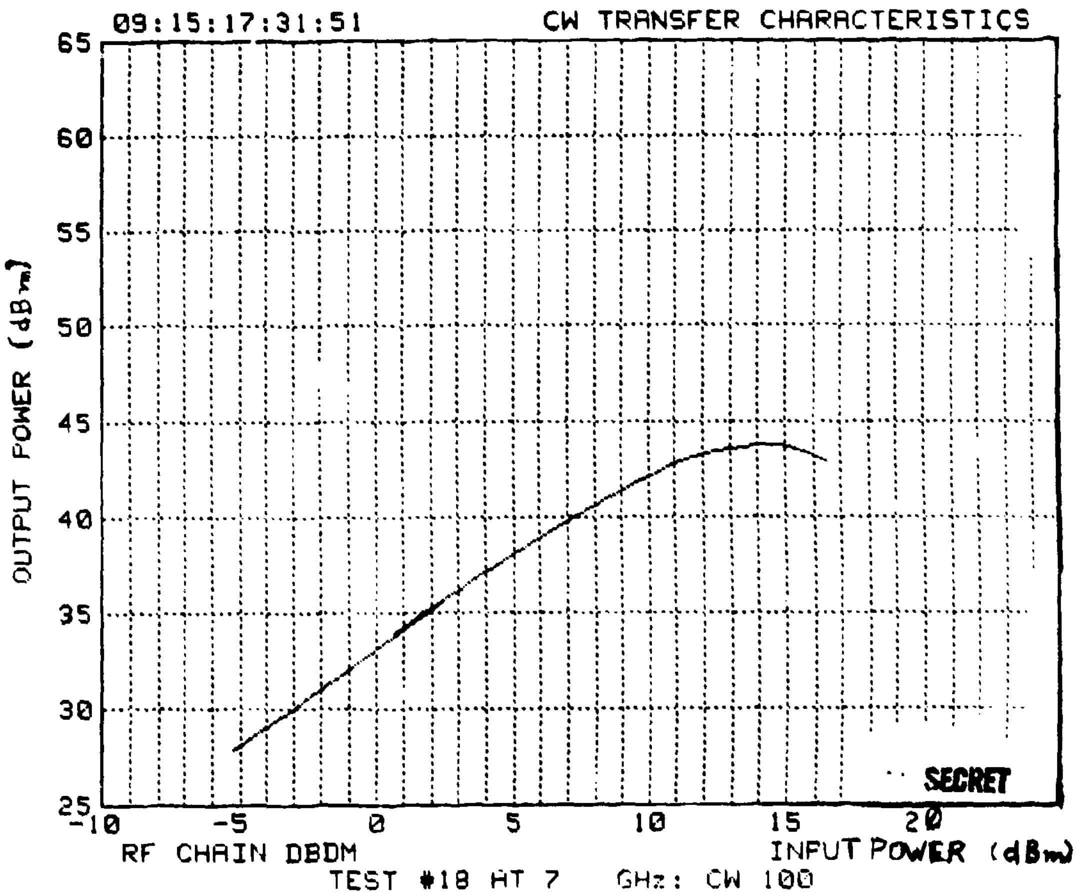
(CW 20 usec PULSEWIDTH [illegible] DUTY CYCLE)




156 028357 001

UNCLASSIFIED

Figure 8?. (U) Modulation Observed with RF Detector (CW Power Output).




186-028664-083

Figure 83. (U) RF Chain DBDM Test No. 18: CW Transfer Characteristics of 7.8 GHz, CW = 100%.

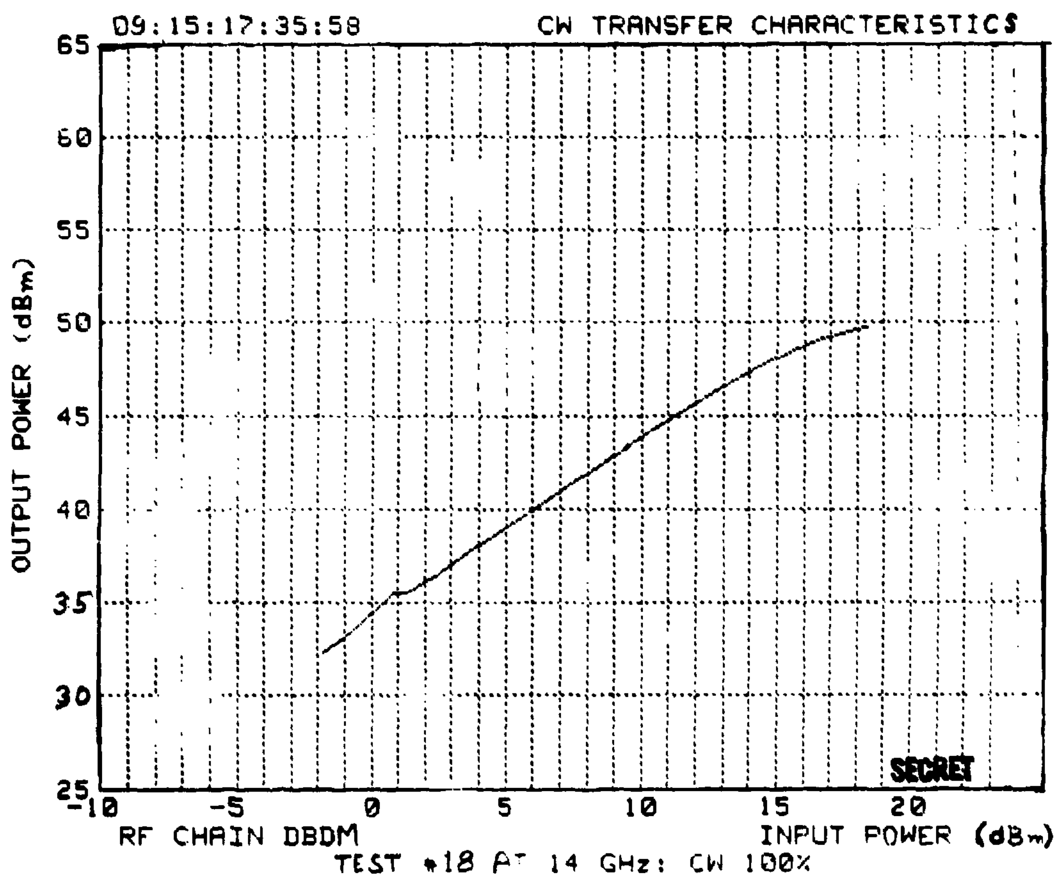
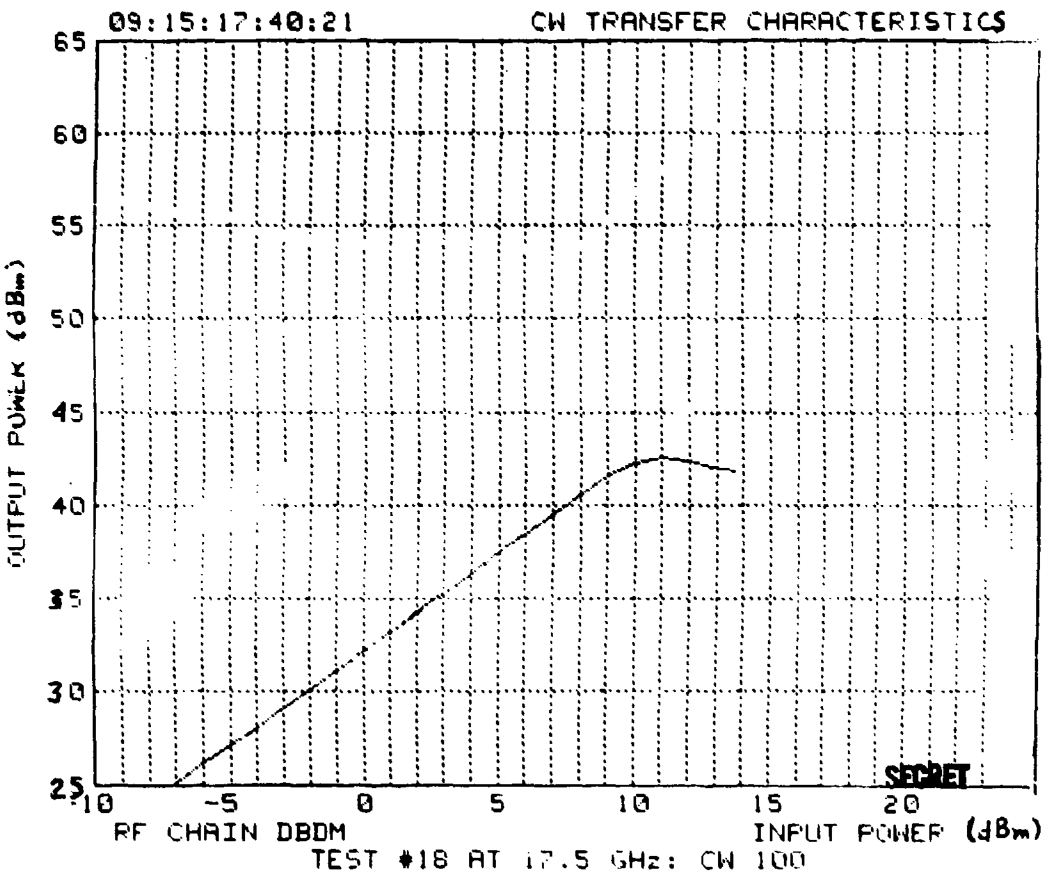



Figure 84. (U) RF Chain DBDM Test No. 18: CW Transfer Characteristics at 14 GHz, CW = 100%.




150-029864-085

Figure 85. (U) RF Chain DBDM Test No. 18: CW Transfer Characteristics at 17.5 GHz, CW = 100%.

b. (U) Results. Figure 86 shows the pulse output power across the frequency band. This is fairly level, except where the output power drops at the high end of the band. Figure 87 shows the detected rf output responses to the pulse modulator commands. The delay is not visible at this time division setting (5 us/div). Figures 88 through 90 show the pulse transfer characteristics at low, middle, and high band frequencies. In each case, the transfer characteristic curves are very linear.

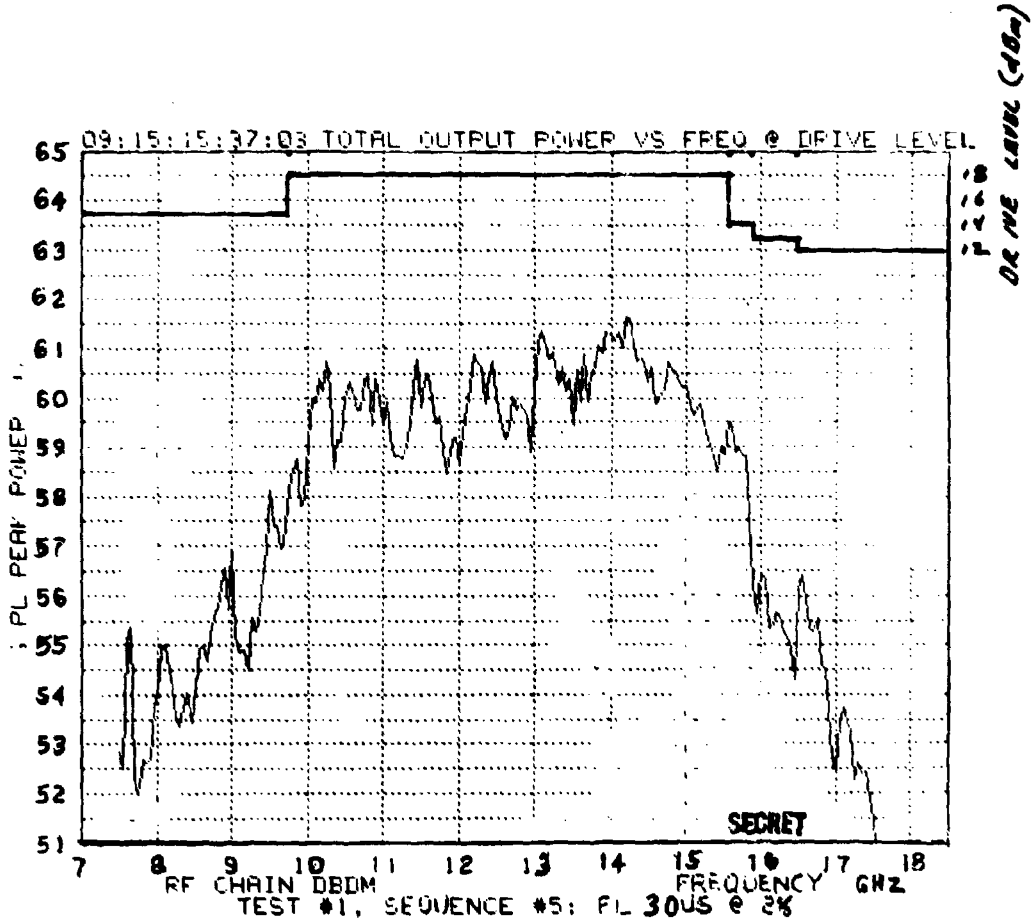
### 4.4.4 CW and Pulse Output.

a. (U) Purpose. The purpose of this test is to observe the power output of the CW and pulse modes together across the frequency band. The test setup is shown in figure 9.

b. (U) Results. This test was run at nominal drive levels, with CW at 100% plus the pulse mode at 2% duty cycle. The output power spectrum is shown in figure 91. Once again, because of the TWT construction, the power output falls at the high end of the band. Figure 92 shows the detected rf output power response to the modulator commands; once again, there is no visible delay.

## 4.5 (U) Testing With the Band III 8% Pulse TWT

(U) To show the high duty cycle capabilities of the rf chain, the high band LRU was tested with a high duty cycle pulse TWT from Hughes installed. The purpose of the testing was to demonstrate the high duty cycle capabilities of the rf chain power supplies and modulators. No attempt was made to optimize the power output of the TWT or to duplicate any previous data taken on the TWT. All testing was conducted at the rated operating duty cycle of the TWT and with a constant rf input drive level to the TWT across the frequency band. The power supplies and modulator used were baseline rf chain equipment.




166-029864-086

Figure 86. (S) RF Chain DBDM Test No. 1, Sequency No. 5: Total Output Power vs. Frequency, PLS = 20 us at 2%.

[illegible] OBSERVED WITH RF DETECTOR

(PULSE 20 μsec [illegible] AT 2 DUTY CYCLE)

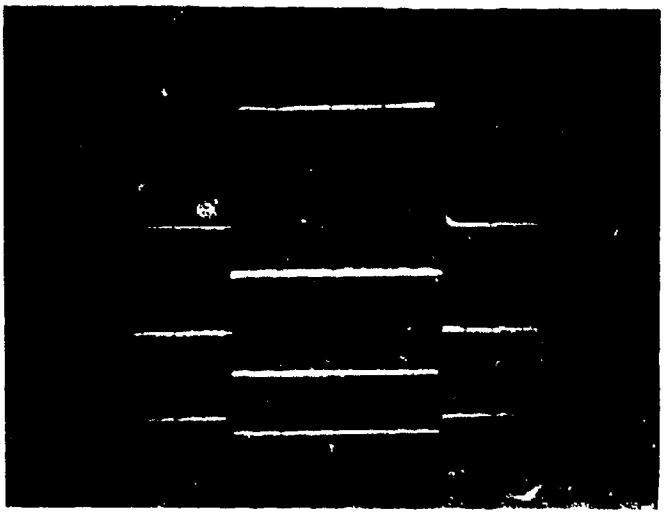



Figure 87. (U) Modulation Observed With RF Detector (Pulse Power Output).

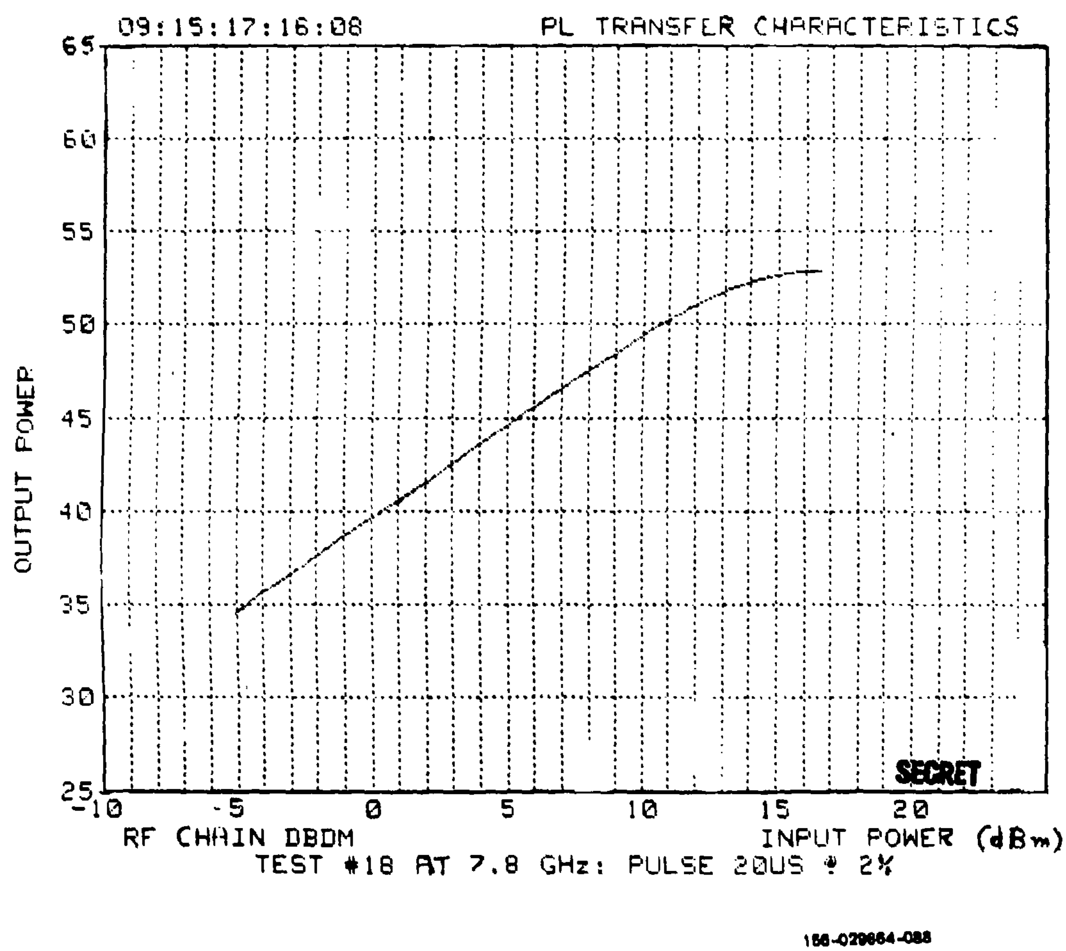
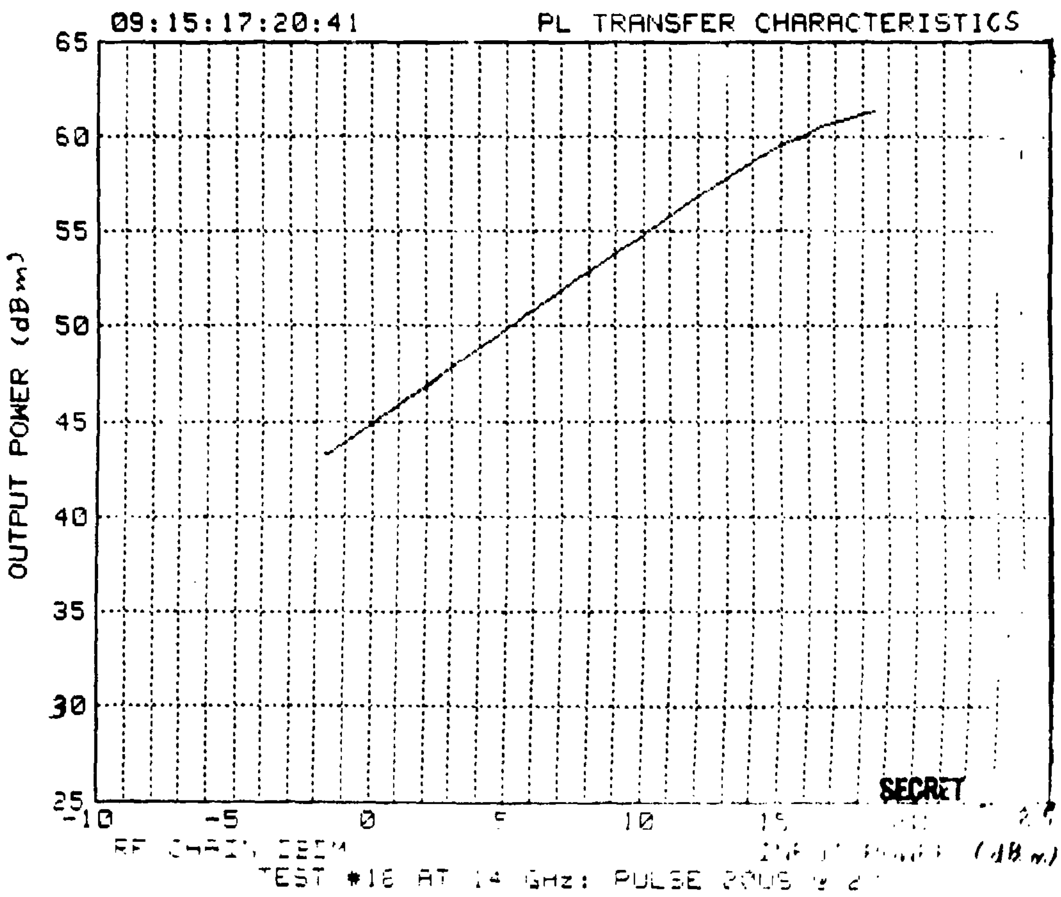
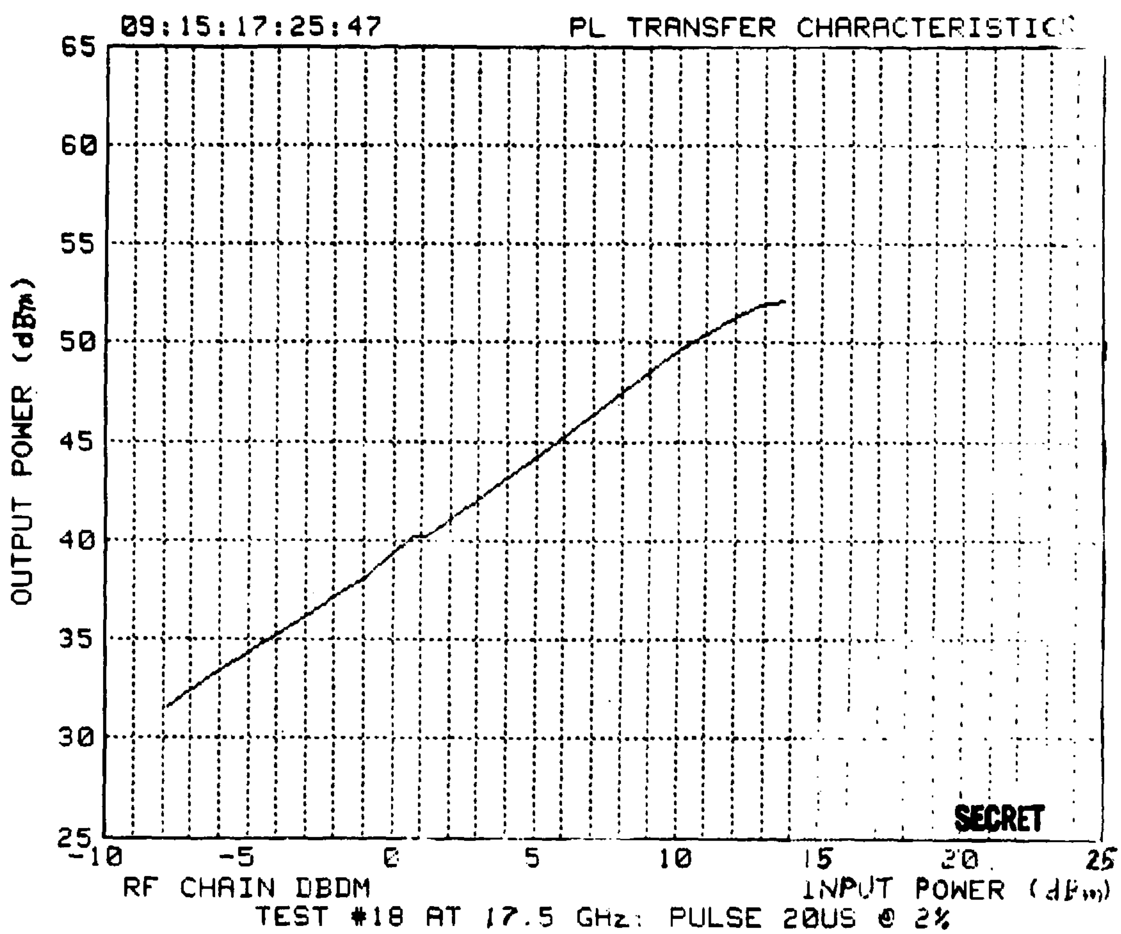



Figure 88. (S) RF Chain DBDM Test No. 18: PLS Transfer Characteristics at 7.8 GHz, PLS = 20 us at 2%.



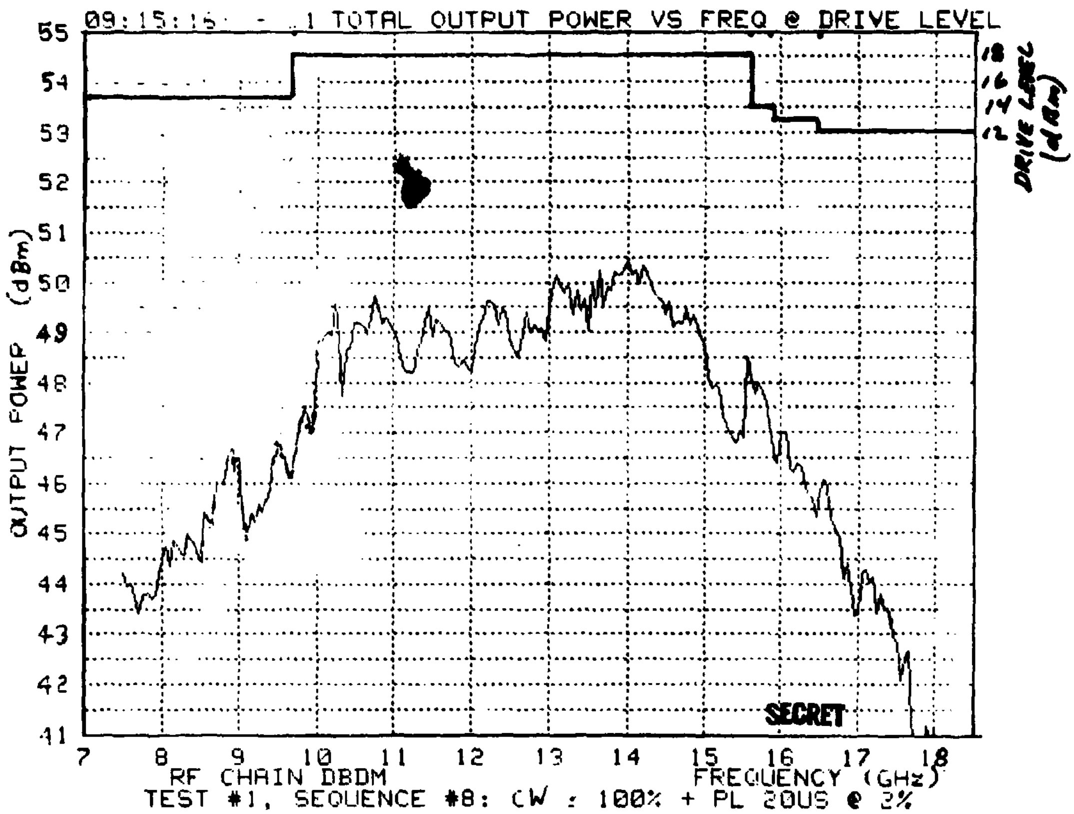

156-029864-089

Figure 89. (S) RF Chain DBDM Test No. 18: PLS Transfer Characteristics at 18 GHz, PLS = 20 us at 2%.




156-029664-090

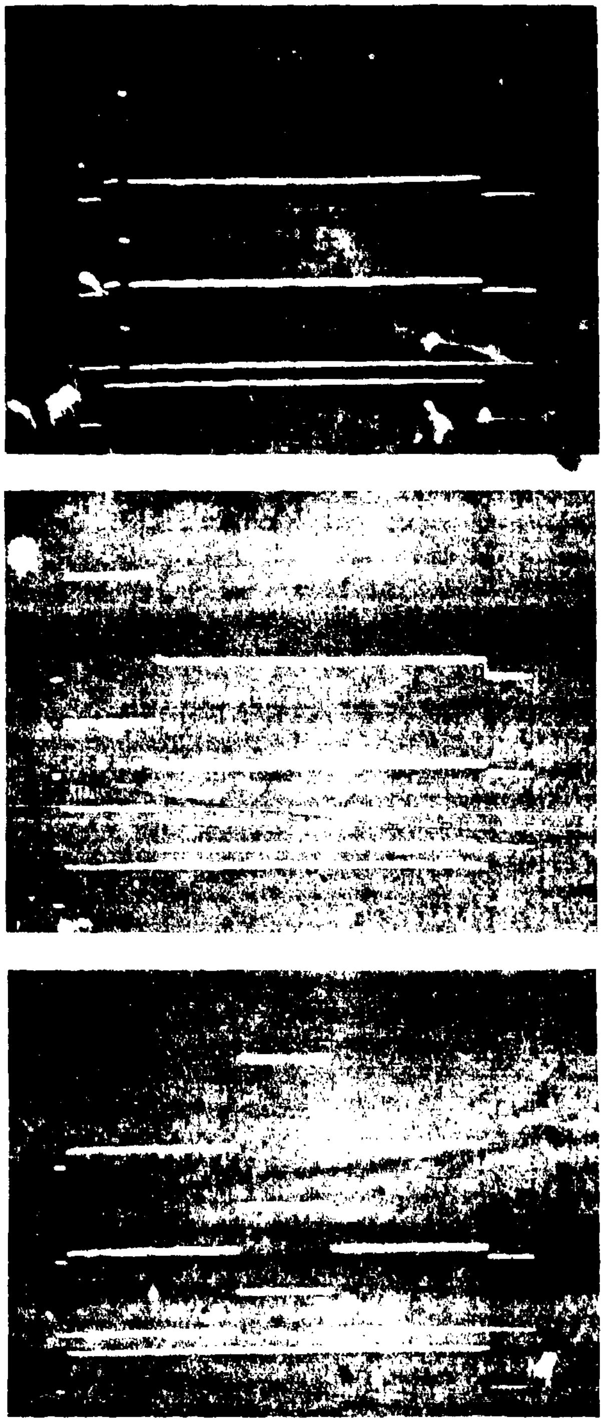
Figure 90. (S) RF Chain DBDM Test No. 18: PLS Transfer Characteristics at 17.5 GHz, PLS = 20 us at 2%.




156-079664-091

Figure 91. (S) RF Chain DBDM Test No. 1, Sequence No. 8: Total Output Power vs. Frequency at Drive Level, CW at 100% plus PLS of 20 us at 2%.

MODULATOR OBSERVED WITH RF DETECTOR
(CW + PULSE)



DETECTED RF
CATHODE CURRENT
PLS MODULATOR ENABLE
CW MODULATOR ENABLE

DETECTED RF
CATHODE CURRENT
PLS MODULATOR ENABLE
CW MODULATOR ENABLE

DETECTED RF
CATHODE CURRENT
PLS MODULATOR ENABLE
CW MODULATOR ENABLE



156-028357 002

Figure 92. (U) Modulation Detected With RF Detector (CW Plus Pulse).

(U) Testing was conducted with only the high duty cycle pulse tube and one modulator installed. At the time of testing only one working modulator was available for use in the amplifier.

(U) Total testing time was approximately ten (10) hours. During the testing period no failures of the high band rf chain LRU were encountered.

4.5.1 (U) TWT Description. The following paragraphs list some of the specifications of the 8% pulse TWT. The tube drawings are contained in Northrop DSD documents 090-001838 and 090-001841, and the specifications in 093-004211. These are some of the specifications:

(S) Frequency Range: The full performance frequency range of the tube is 8.9 GHz to 18.0 GHz.

(S) Rated Fundamental Power Output: The minimum output power of this TWT at 8% duty cycle is 1500 watts peak.

(U) Duty Cycle: The duty cycle for this TWT is 8% maximum; the pulse width is in the range of 0.1 us to 30 us.

(U) Small Signal Gain: The small signal gain, when tested with a leveled rf input equal to that required to achieve a 7 dB reduction in rf output from the previously stated minimum, is in the range of 44 dB to 54 dB within the TWTs frequency range.

(U) Noise Output: With the input port terminated in 50 ohms and the output port terminated in a flat attenuator, the noise output does not exceed -10 dBm/MHz when measured through a bandpass filter with a 3 dB bandwidth equal to or less than 100 MHz.

(U) With nominal input drive, the total harmonic power is at least 5 dB below fundamental power output.

4.5.2 (U) List of Tests. The electrical performance tests conducted on the rf chain high band LRU with the 8% pulse TWT are listed below:

1. Duty Cycle Limiting
2. Pulse Width Limiting
3. Total Power Output vs. Frequency
4. Small Signal Gain vs. Frequency
5. Gain Variations
6. Harmonic Power vs. Frequency

4.6 (U) Detailed Test - Data - 8% Pulse TWT

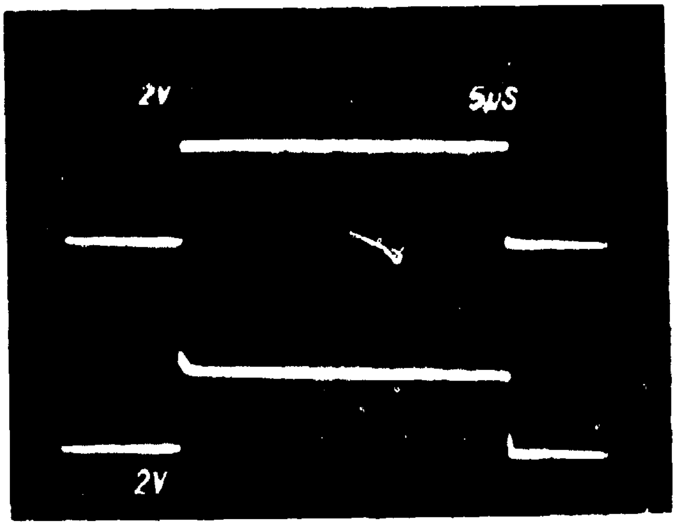
(U) The purpose of the following tests is to demonstrate the high duty cycle capabilities of the rf chain. All testing was conducted using rated duty cycle (8%) and maximum pulse width (32 us) for the pulse TWT. Figure 93 shows the pulse modulator enable signal; and figure 94 shows the pulse duty cycle. Figure 95 shows a spectrum analyzer display of the rf output of the rated operating pulse width and duty cycle.

4.6.1 (U) Duty Cycle Limiting

a. (U) Purpose. The purpose of this test is to demonstrate the capability of the rf chain to limit the duty cycle to the rated duty cycle of the TWT.

b. (U) Results. The results of this test are shown in table 5 and figure 96. The test was conducted by maintaining the modulator enable pulse at 32 us and decreasing the time between pulses from 400 us to 250 us. As the duty cycle of the input command was increased, the rf output pulse width decreased, maintaining the 8% duty cycle.

4.6.2 (U) Pulse Width Limiting.




PULSE GENERATOR OUTPUT

MODULATOR ENABLE COMMAND

156-029664-093

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Figure 43. (S) RF Chain High Band, PLS Modulator Enable Command, 32 us Pulse Width.

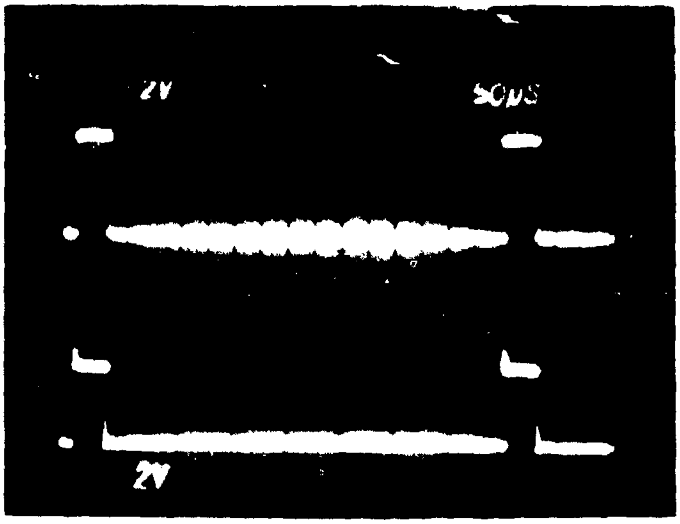


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Figure 94. (S) RF Chain High Band, 8% Duty Cycle, 32 us Pulse Up Out of a 400 us Period.

156-029664-095

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Figure 95. (S) RF Chain High Band, Spectrum Analyzer Display at 8% Duty Cycle.

Table 5. (U) High Band RF Chain Duty Cycle Limiting.

| | PULSE WIDTH | PERIOD | DUTY CYCLE |
|---|---|---|---|
| Modulator Enable | 32 us | 245 us | 13% |
| Detected RF Output | 20 us | 245 us | 8.1% |

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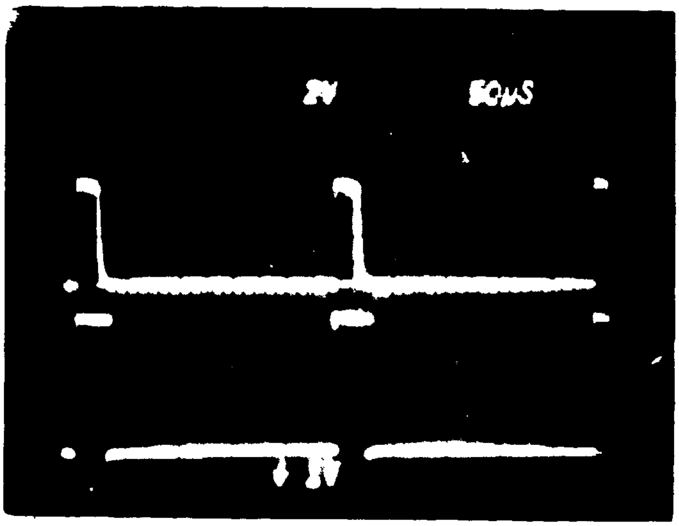

DETECTED RF OUTPUT

MODULATOR ENABLE COMMAND

UNCLASSIFIED

Figure 96. (U) RF Chain High Band, Duty Cycle Limiting.

a. (U) Purpose. The purpose of this test is to demonstrate the ability of the modulator to limit the pulse width of the rf output is the rated output pulse width of the TWT.

b. (U) Results. The test results are shown in table 6 and figure 97. This test was conducted by increasing the modulator input command pulse from 32 us to 50 us. The modulator limited the output pulse to 34 us.

4.6.3 (U) Total Power Output vs. Frequency

a. (U) Purpose. The purpose of this test is to demonstrate the ability of the RF Chain Power Amplifier to support the 8% duty cycle pulse tube across the frequency band.

b. (U) Results. This test was conducted using a constant drive level across the band. The results are shown in figure 98. The power output, with no attempt at power output optimization, meets the rf chain requirements over almost the entire frequency band.

4.6.4 (U) Small Signal Gain vs. Frequency

a. (U) Purpose. The purpose of this test is the same as that for the test of 4.6.3. The test was conducted in the same manner, except that the input drive level was reduced by 15 dB.

b. (U) Results. The test results are shown in figure 99. The results show that the rf chain does support the tube across the frequency band for the reduced drive level.

4.6.5 (U) Gain Variations

a. (U) Purpose. The purpose of this test was to demonstrate the ability of the rf chain to support the 8% duty cycle pulse tube at reduced drive levels across the frequency band.

Table 6. (U) High Band RF Chain, Pulse Width Limiting.

| | PULSE WIDTH | PERIOD |
|---|---|---|
| Modulator Enable | 50 us | 500 us |
| Detected RF Output | 34 us | 500 us |

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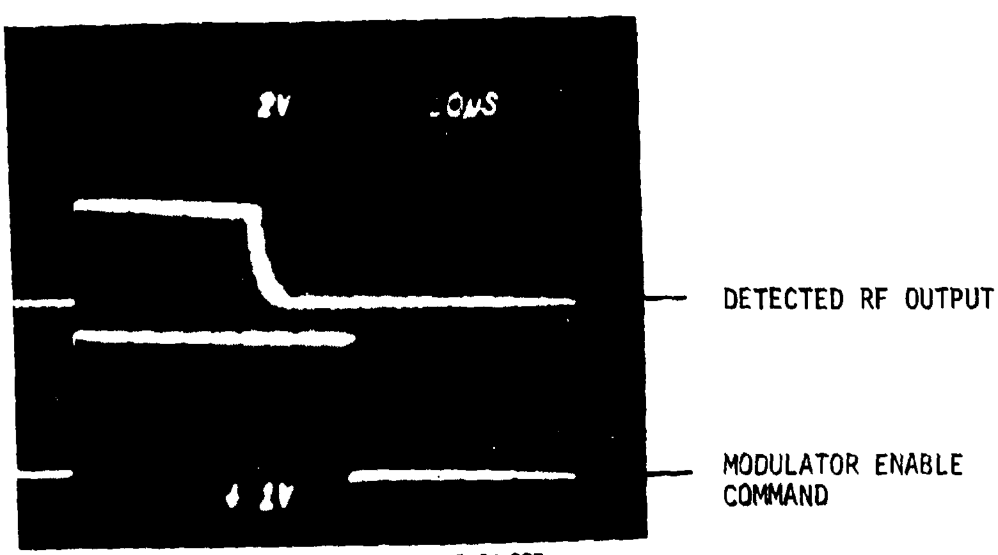


UNCLASSIFIED

Figure 97. (U) RF Chain High Band, Pulse Width Limiting.

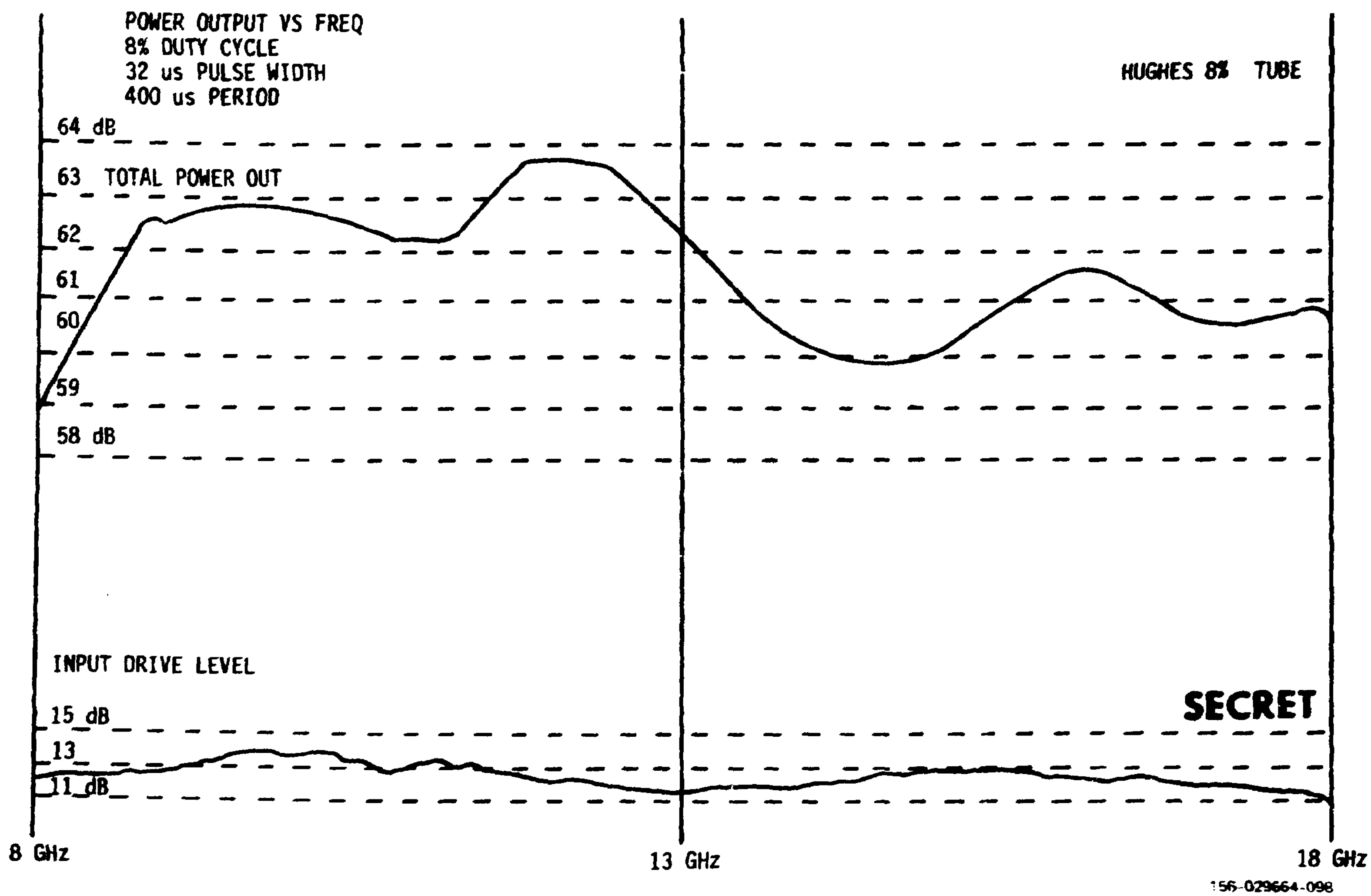


Figure 98. (S) RF Chain High Band, 8% Hughes Pulse Tube PLS Total Power Output vs. Frequency, PLS us at 8%.

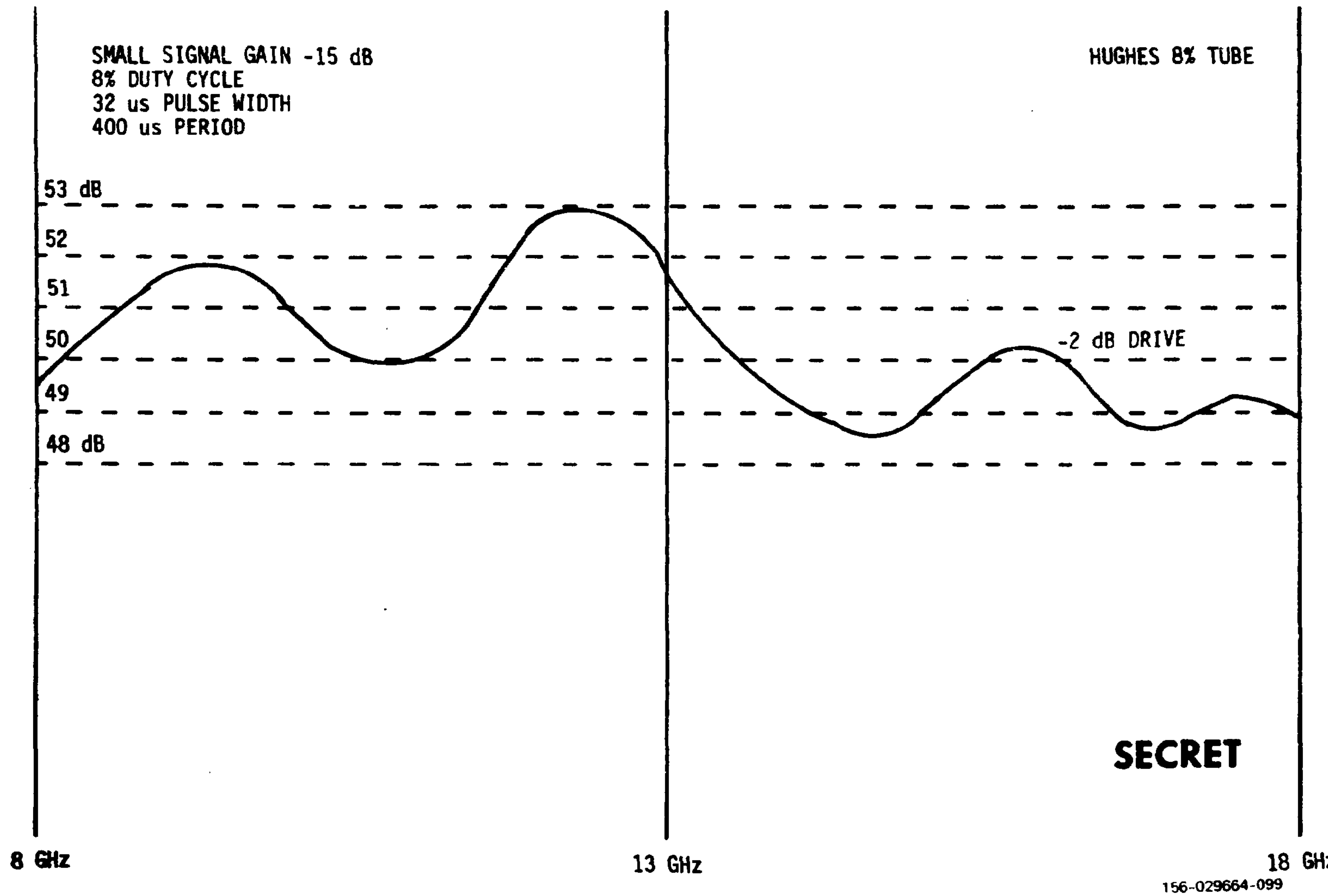


Figure 99. (S) RF Chain High Band, 8% Hughes Pulse TWT PLS Small Signal Gain vs. Frequency, PLS = 32 us at 8%.

b. (U) Results. The test results are shown in figure 100. The input drive levels were reduced by 3 dB for each test sweep of the band, and the gain variation at different drive levels recorded. Each of the drive levels produced an output curve of approximately the same shape.

4.6.6 (U) Harmonic Power vs. Frequency

a. (U) Purpose. The purpose of this test was to demonstrate that the RF Chain Power Amplifier will support the 8% duty cycle pulse TWT across the frequency band without generating excessive harmonics.

b. (U) Results. The results are shown in figure 101. The harmonic power is down about 15 dB average from the total power output across the frequency band.

4.7 (U) Testing With The 6 dB Pulse-Up TWT

(U) To show the versatility of the rf chain, the high band LRU was tested with the 6 dB pulse-up TWT. This testing required a special tri-level modulator for the rf chain. The high voltage power supply and the modulator were left unencapsulated and mounted in a tank filled with coolant oil (FC-48). Since the 6 dB pulse-up TWT is not intended for use in the rf chain, the HVPS and modulator were built for ease of modification rather than form factor.

(U) Although the pulse-up TWT did not meet specifications, it was sufficient to show the pulse-up capability of the rf chain power amplifier, and particularly to demonstrate the performance of the new tri-level modulator in an actual amplifier.

4.7.1 (U) 6 dB Pulse-Up TWT Description: The following paragraphs list some of the specifications of the 6 dB pulse-up TWT. The specifications and drawing for this tube are contained in Northrop DSD documents 093-006396 and 090-001870, respectively. These are some of the relevant specifications:

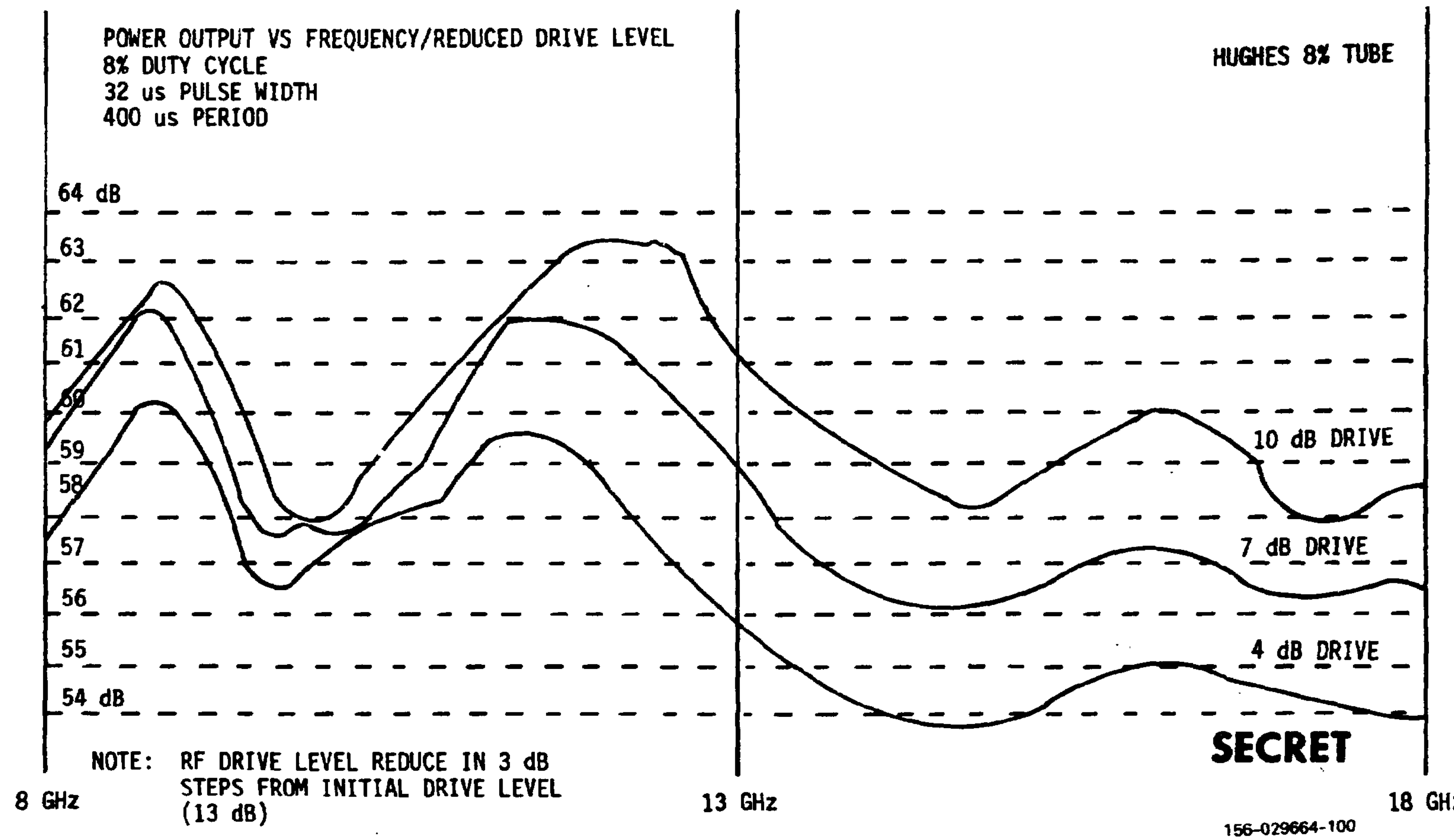


Figure 100. (S) RF Chain High Band, 8% Hughes Pulse Tube, PLS Power Output vs. Frequency/Reduced Drive Level, PLS=30 us at 8%

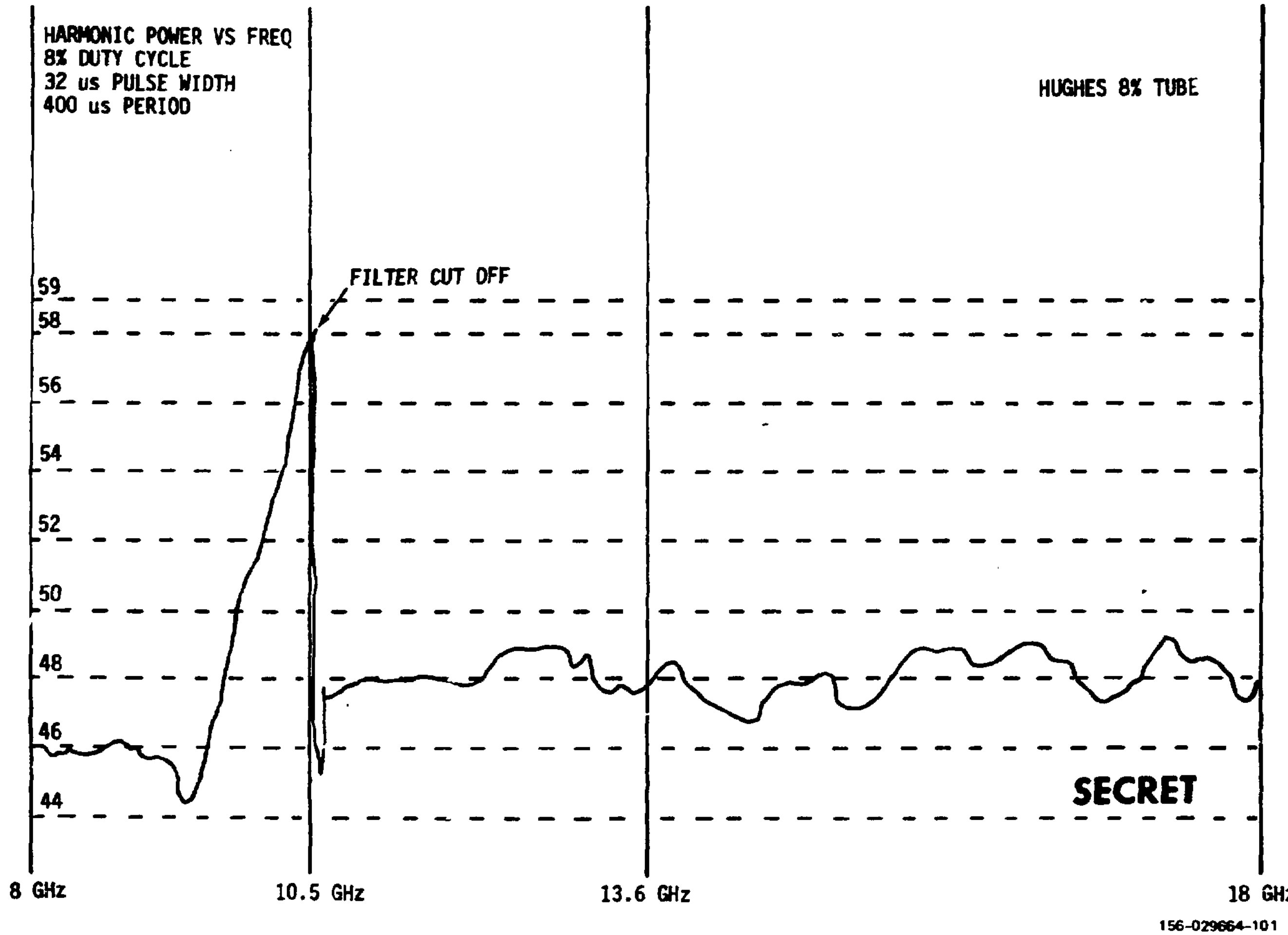


Figure 101. (S) RF Chain High Band, 8% Hughes Pulse Tube PLS Harmonic Power vs. Frequency, PLS = 32 us at 8%.

(S) Frequency Range: This TWT amplifies rf signals within the frequency range of 7.5 GHz to 18.2 GHz.

(S) Rated Fundamental Output power: The minimum output power of this TWT is:

| Frequency | CW Mode Output Power | Pulse Mode Peak Output Power |
|---|---|---|
| 7.5 GHz | 50.0 dBm | 56.0 dBm |
| 7.8 GHz | 51.8 dBm | 57.8 dBm |
| 17.0 GHz | 51.8 dBm | 57.8 dBm |
| 18.2 GHz | 50.0 dBm | 56.0 dBm |

(C) Duty Cycle: The maximum duty cycle of this TWT is 100 percent in CW mode and 25 percent in pulse mode. The maximum pulse duration is 25us.

(U) Small Signal Gain: The CW mode small signal gain is the range of 41 dB to 51 dB. The pulse mode small signal gain is in the range of 50 dB to 60 dB.

(U) TWT Difficulties: This TWT did not meet many of the specifications. For example, output power and small signal gain were below their specified levels over large portions of the frequency band. Because the tube performance was poor, the maximum duty cycle used in testing was limited to 20 percent to prevent damage to the tube. Also, the output power in the pulse mode was only 2 dB to 3 dB up over CW mode output power when the tube was operated at saturated output power, and the TWT was not equalized - it required more drive in the lower half of the frequency band than was specified.

(U) Even though the TWT did not meet specifications, it was completely adequate to show the rf chain's capability to operate with a dual mode TWT installed.

4.7.2 (U) List of Tests: The electrical performance tests conducted on the rf chain high band LRU with the 6 dB pulse-up TWT are listed below:

1. Total power output vs. frequency
2. Fundamental power output vs. frequency
3. Small signal gain
4. 6 dB pulse-up
5. Dual-Mode operation

4.8 (U) Detailed Test Data - 6 dB Pulse-Up TWT

(U) The detailed test data for each test provided in this section is preceded by introductory paragraphs indicating the purpose of each test, and a summary of the test results. The test setup for each of these tests is that shown in figure 9, except that the data recorder was not available. Therefore, data points were recorded by hand.

(U) This testing was conducted to show the compatibility of the standard rf chain with the 6 dB pulse-up TWT; therefore, only those tests which show this compatibility were performed.

4.8.1 (U) Total Power Output

a. (U) Purpose. The purpose of this test is to show the rf chain unit's power output for both the CW and the pulse modes.

b. (U) Deviations. Since this TWT did not have an equalized input, the input drive level had to be adjusted at each test point to get maximum power from the tube. The rf chain was not able to drive the tube into saturation over much of the lower half of the frequency band because the tube exceeded drive specifications, requiring approximately 24 dB of drive in the lower half of the band. The maximum drive available from the rf chain was 20 dB. Two separate test runs were made.

(U) The first run was made with the input drive adjusted to give maximum CW power output, with power readings taken in both the CW and the pulse modes. The second run was made with the input drive adusted to give maximum pulse power output, and again readings were taken in both the CW and pulse modes.

c. (U) Results. See Figures 102 and 103. These results show that the tube did not meet the power output specifications over most of the frequency band. They also show that the pulse mode went into saturation before the CW mode over most of the tube's operating frequency band, and that the tube did not give 6 dB pulse-up operation. Pulse-up operation ranged from 2 dB to 4 dB across the band.

4.8.2 (U) Fundamental Power vs. Frequency

a. (U) Purpose. The purpose of this test is to show the output power of the rf chain at each fundamental frequency after all harmonics are filtered out.

b. (U) Results. Figure 104 shows both CW and pulse power output. The tube failed to meet the power output specifications over most of the frequency band. It also failed to meet the 6 dB pulse-up specification.

4.8.3 (U) Small Signal Gain

a. (U) Purpose. The purpose of this test is to demonstrate the small gain across the frequency band, with the rf input drive levels reduced by 15 dB from their nominal values.

b. (U) Results. See figures 105 and 106. Figure 105 shows the small signal gain of the CW mode. The tube failed to meet the gain specifications over the lower third of the frequency band. Figure 106 shows the small signal gain of the pulse mode. Again the tube failed to meet the gain specifications

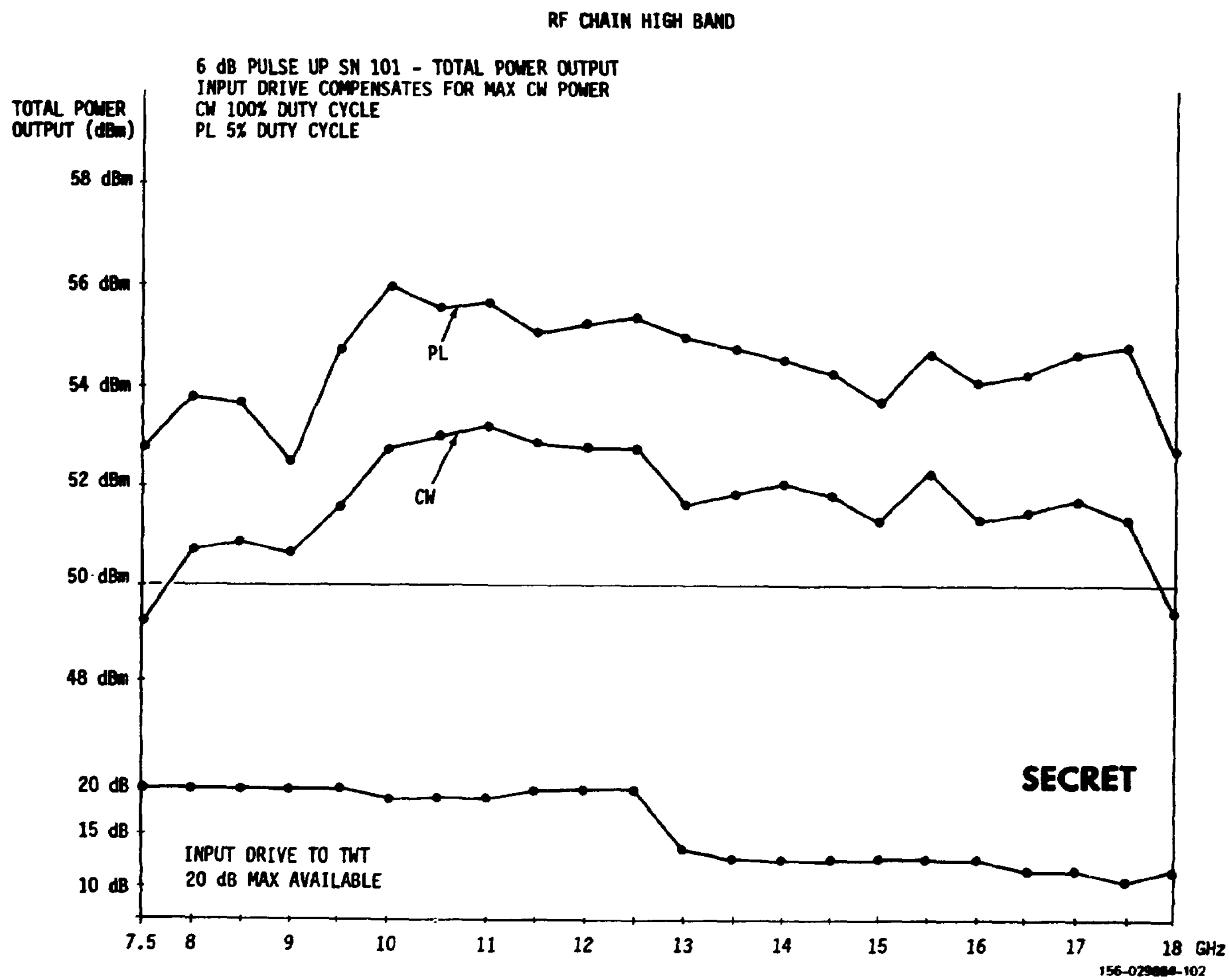


Figure 102. (U) RF Chain High Band, 6dB Pulse-up Tube, Total Power Output vs. Frequency, Max CW Power.

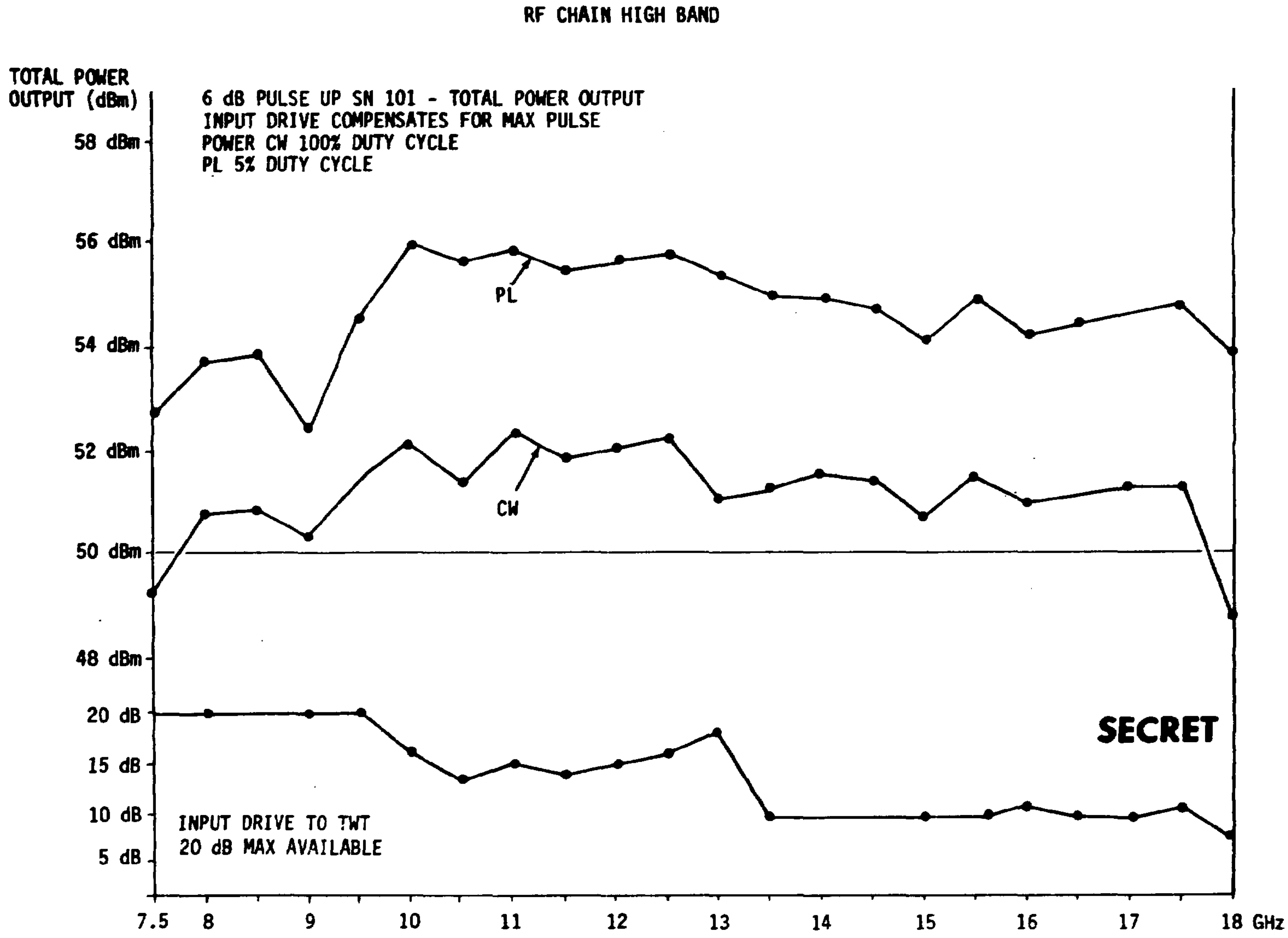


Figure 103. (U) RF Chain High Band, 6dB Pulse-up Tube, Total Power Output vs. Frequency, Max Pulse Power.

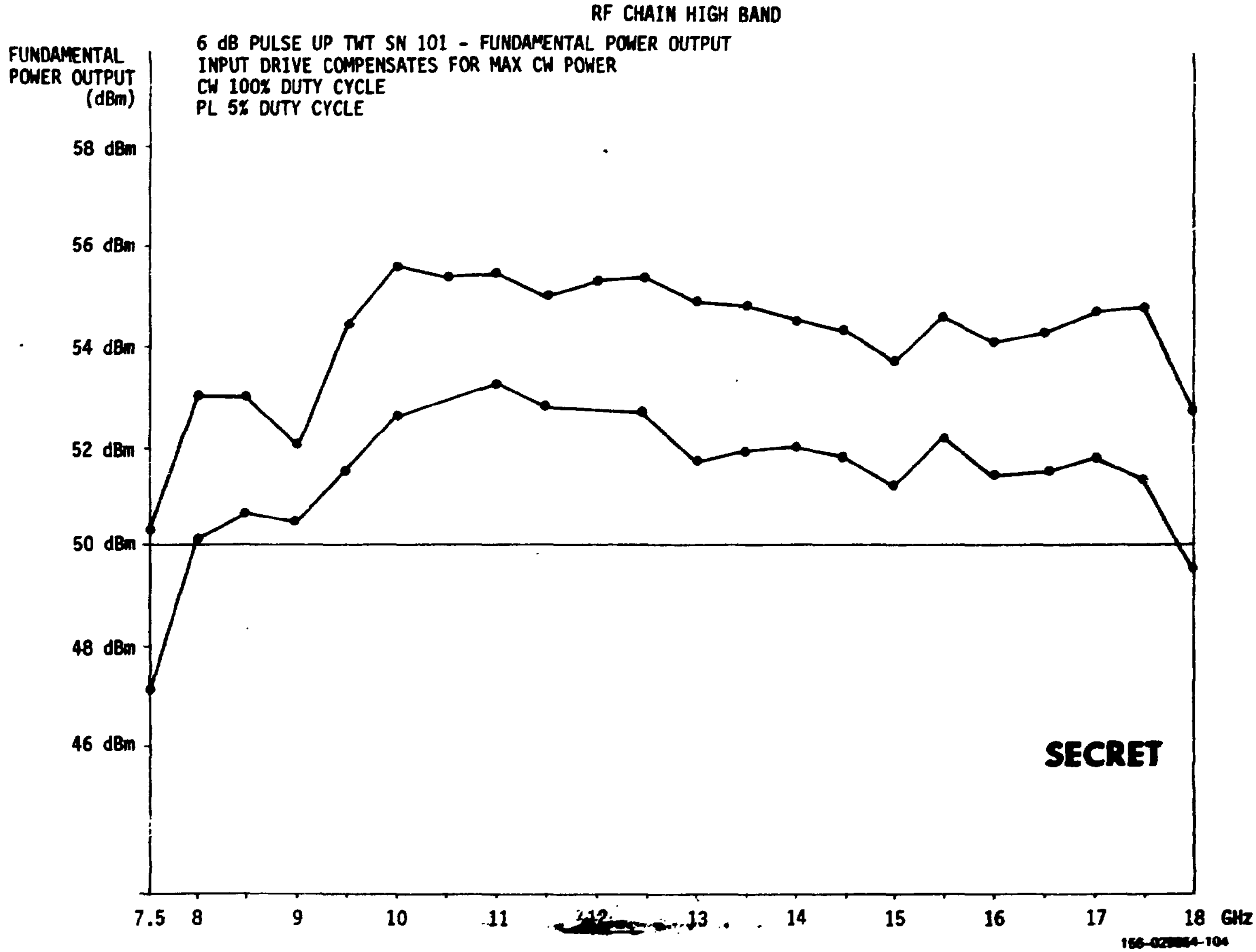


Figure 104. (U) RF Chain High Band, 6dB Pulse-up Tube, Fundamental Power Output vs. Frequency, Max CW Power.

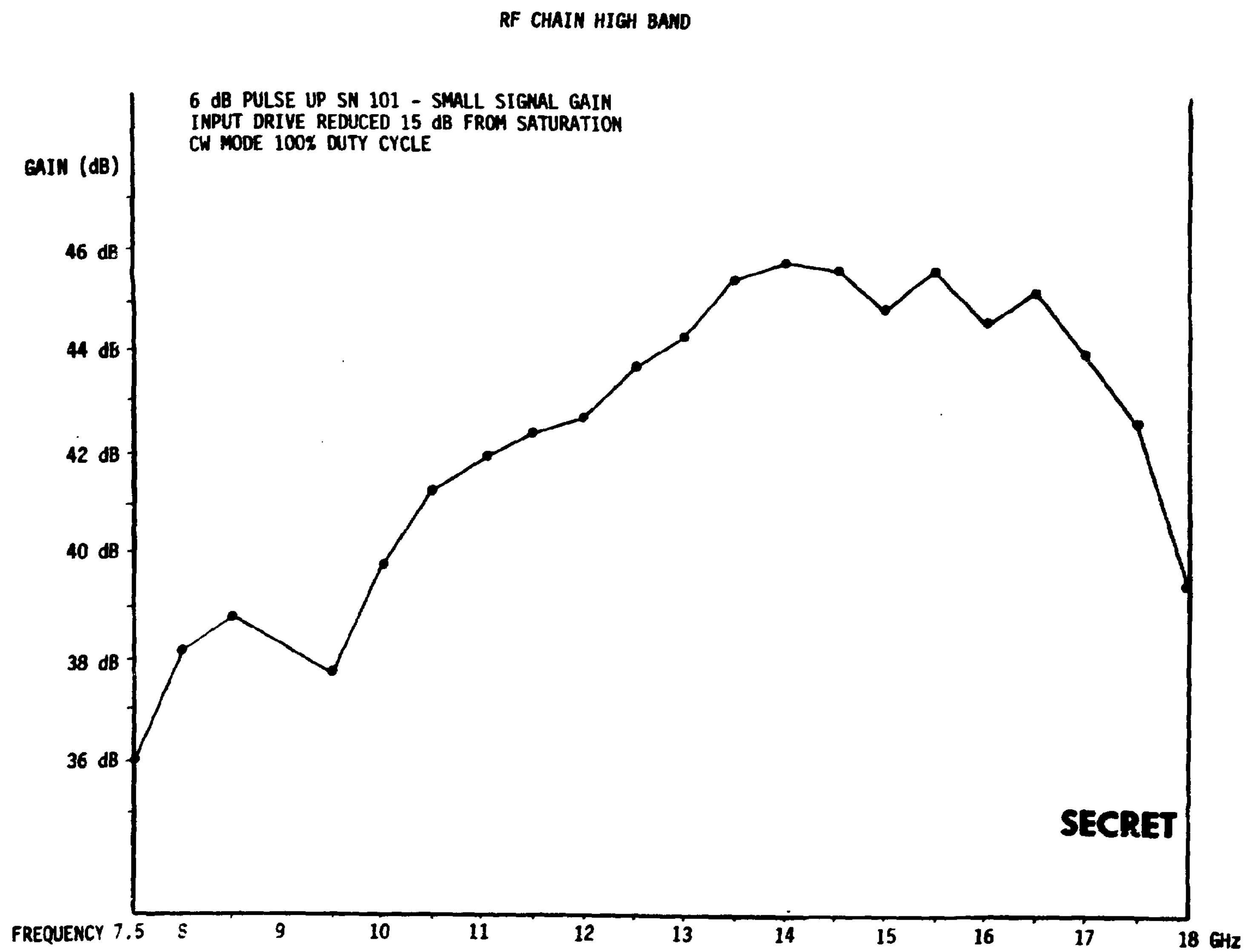


Figure 105. (U) RF Chain High Band, 6dB Pulse-up, Small Signal Gain vs. Frequency, CW Mode.

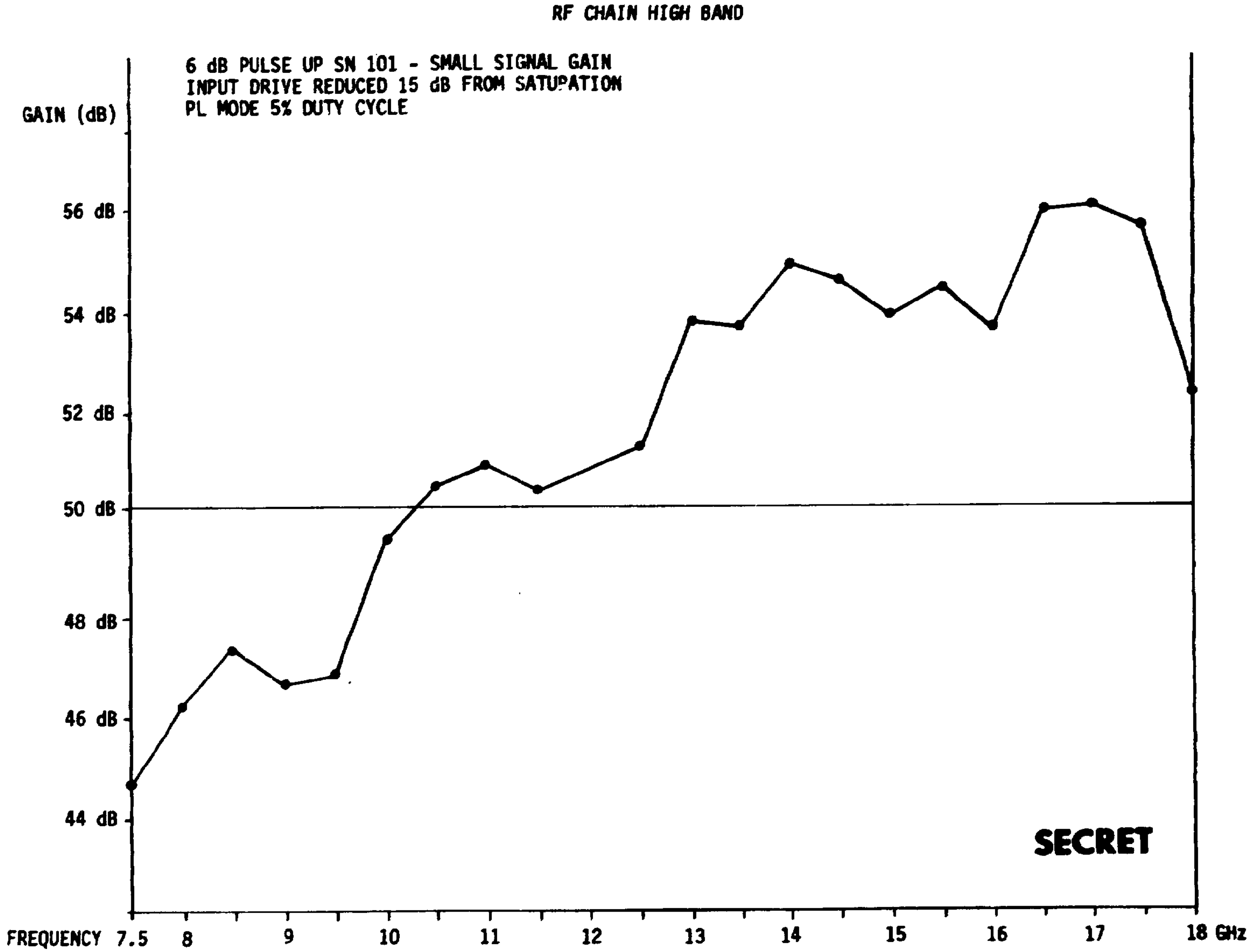


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Figure 106. (U) RF Chain 6dB Pulse-up, Small Signal Gain vs. Frequency, Pulse Mode.

(U)over the lower third of the frequency band. It should be also be noted that the gain in the pulse mode is significantly greater than 6 dB above the CW mode gain level across the frequency band.

4.8.4 (U) 6 dB Pulse-up

a. (U) Purpose. The purpose of this test to see if by reducing the input drive level to the tube, a point could be found where the tube would actually operate in a 6 dB pulse-up condition.

b. (U) Results. By slowly reducing the input drive level at each test frequency, a point was found where the tube did operate at 6 dB pulse-up. Figure 107 shows the CW and pulse power output at the point where 6 dB pulse-up operation was achieved. Figures 108 and 109 show the spectrum analyzer display.

4.8.5 (U) Dual Mode Operation

a. (U) Purpose. The purpose of this test is to demonstrate the dual mode capabilities of the rf chain.

b. (U) Results. Figure 110 shows the CW and pulse modulator commands, and the TWT beam current. This figure shows the TWT beam current at the CW level, with an increase in beam current during the pulse-up command. Figures 111, 112 and 113 show the detected TWT output. Figure 111 shows this output for CW mode only; figure 112 shows it for pulse mode only; figure 113 shows it for CW and pulse-up operation.

c. (U) Additional Test Conducted. Figure 114 shows the detected TWT output with the tube operating in the pulse mode at a 20 percent duty cycle. The tube duty cycle operation was limited to 20 percent because of the poor performance of the tube.

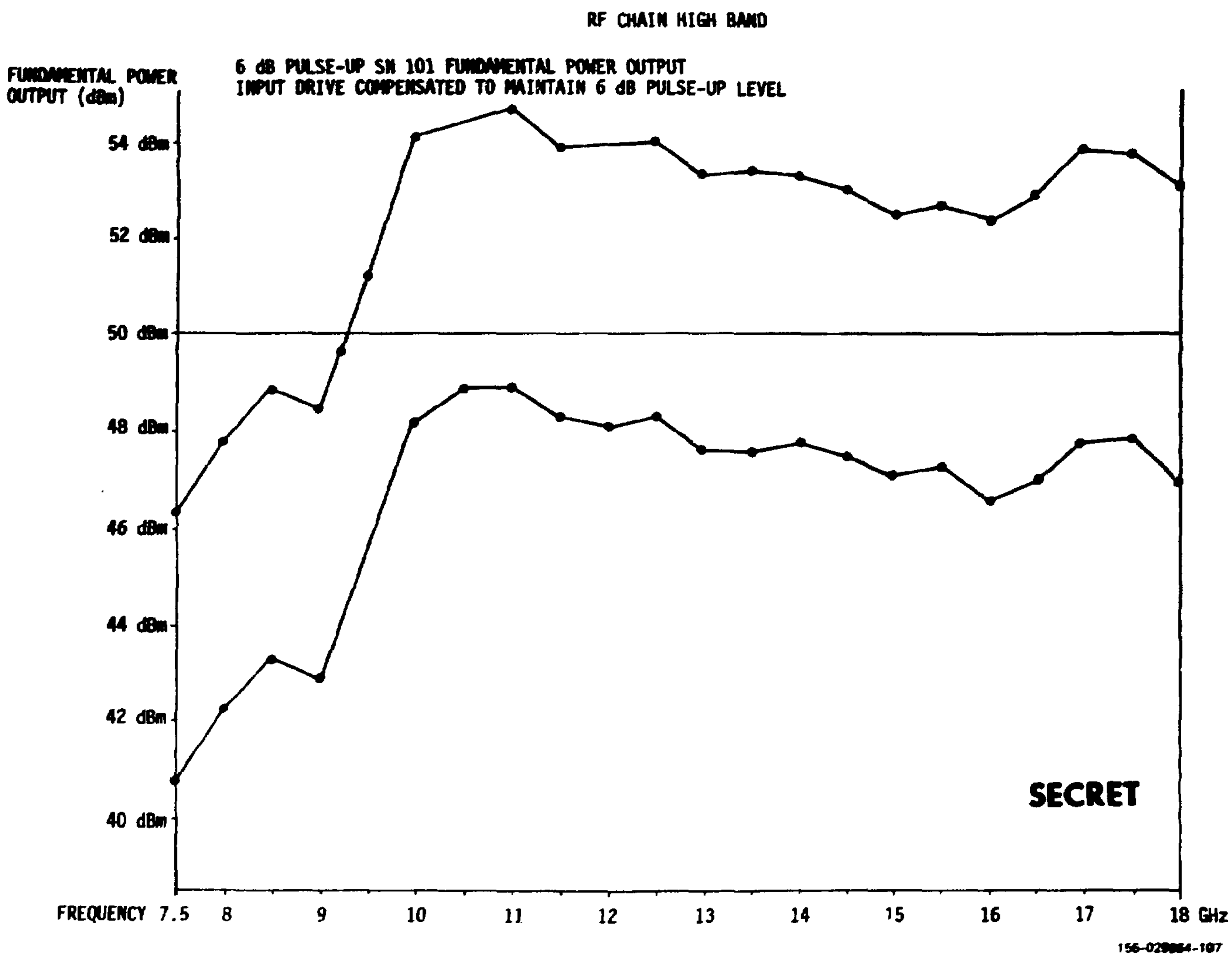


Figure 107. (U) RF Chain High Band, 6dB Pulse-up Tube, 6dB Pulse-up Level.

SPECTRUM ANALYZER
DISPLAY OF TWT OUTPUT
SHOWING CW AND PULSE
OPERATION. PULSE
OUTPUT 6 dB HIGHER THAN
THE CW OUTPUT

SCALE 10 dB/DIV

100% CW
5% PULSE

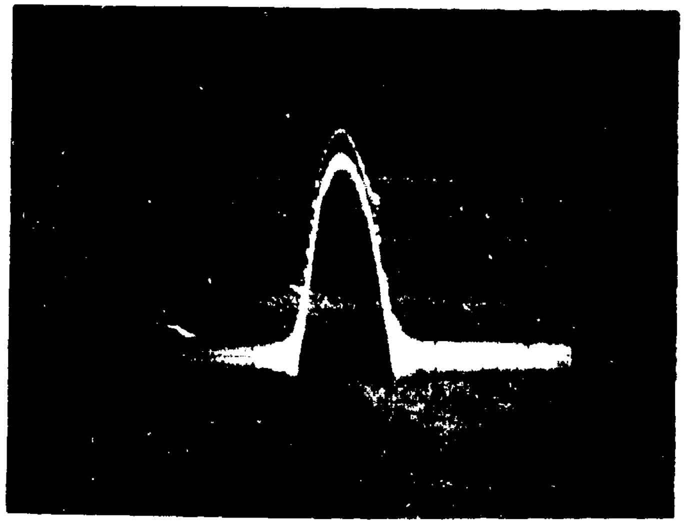

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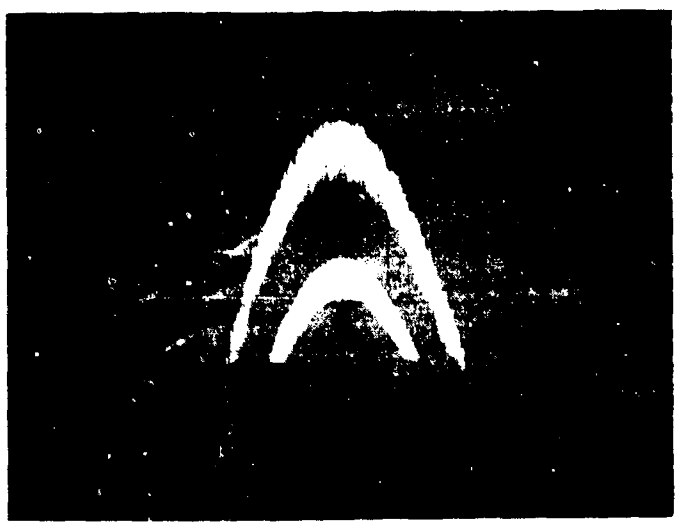
Figure 108. (U) 6dB Pulse-up Test, Full View.

SPECTRUM ANALYZER
DISPLAY OF TWT OUTPUT
SHOWING CW AND PULSE
OPERATION. PULSE
OUTPUT 6 dB HIGHER THAN
THE CW OUTPUT

SCALE 2 dB/DIV



156-029664-109

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Figure 109. (U) 6dB Pulse-up Test, Magnified View.

RF CHAIN HIGH BAND

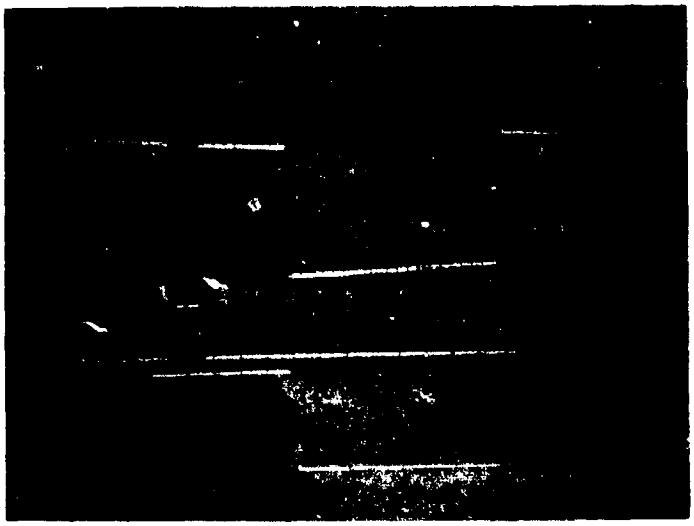
6 dB PULSE UP TWT SN NO. 101

TWT BEAM CURRENT

100 MA/DIV
250 MA CW
380 MA DURING PULSE-UP

PULSE MODULATOR ENABLE
25 us (5% DUTY)

CW MODULATOR ENABLE



156-029664-110

**UNCLASSIFIED**

Figure 110. (U) TWT Beam Current vs. Modulator Commands.

DETECTED TWT OUTPUT

CW MODULATOR ENABLE

50% DUTY CYCLE

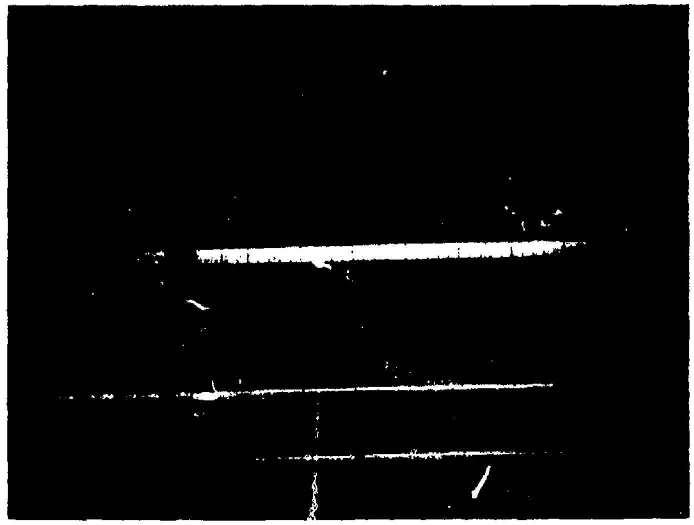
156-029664-111

**UNCLASSIFIED**

Figure 111. (U) CW Mode Output vs. Modulator Enable.

DETECTED TWT OUTPUT

PULSE MODULATOR ENABLE
25 us (5% DUTY)



156-029664-112

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Figure 112. (U) TWT Pulse Mode Output vs. Modulator Enable.

DETECTED TWT OUTPUT
(CW OUTPUT 50% DUTY
WITH 25 us PERIOD
OF PULSE UP POWER
OUTPUT)

PULSE MODULATOR ENABLE
(5% DUTY CYCLE)

CW MODULATOR ENABLE
(50% DUTY CYCLE)

156-029664-113

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Figure 113. (U) TWT Combined Mode Output vs. Modulator Enable.

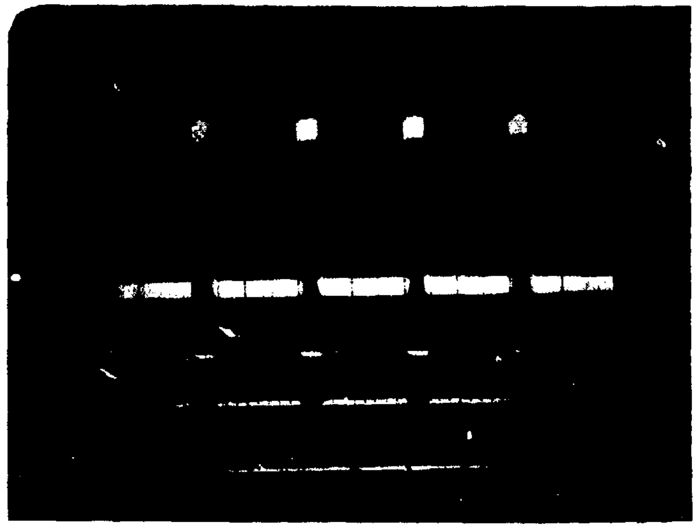
20% DUTY CYCLE

20 us PULSE WITH
100 us PERIOD

DETECTED TWT
OUTPUT

PULSE ENABLE

DUTY CYCLE LIMITED
TO 20% PULSE OPERATION
BECAUSE OF POOR TUBE
PERFORMANCE.



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**SECRET**

Figure 114. (S) 20% Duty Cycle Test.

4.8.6 (C) Because of the poor TWT performance, pulse-up operation during the combined CW and pulse mode was limited to a maximum pulse width of 25 us and a duty cycle of not greater than 5 percent to prevent damage to TWT. When the 6 dB pulse-up modulator was tested separately, the pulse width and duty cycle limiting features did perform as required. These tests were not performed with the TWT.

(U) Even though the 6 dB pulse-up TWT did not meet its specifications, this testing did demonstrate the versatility of the rf chain in general and the tri-level modulator in particular by showing that these devices are capable of pulse-up operation as well as the other modes of operation detailed in this report.

# SECTION V

## CONCLUSIONS AND RECOMMENDATIONS(U)

(U) This testing provides conclusive evidence that the standard rf chain high band and low band LRUs meet or exceed all specifications of the rf chain program. Although in some cases the rf chain amplifiers did not meet specifications because of the TWTs used, comparison of the tube specifications with the rf chain performance using those tubes makes it clear that the rf chain could exceed its specifications in most cases, given the appropriate tubes.

(U) The testing also showed that the rf chain met its design objectives of high reliability, compatibility with various TWTs, commonality between LRUs, and easy maintenance.

(U) Recommendations. The standard rf chain could be further improved by using updated modulators and power supplies. This would have the effect of making the rf chain even more compatible with TWTs - when TWTs with higher output powers become available, the rf chain with updated power supplies could drive them without modification. Updated modulators would help cut down space requirements, and increase the effectiveness of the rf chain in ECM applications.

Distribution List for AFWAL-TR-82-1160, RF Chain Final
Technical Report, Contract No. F33615-79-C-1821

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To Annette

# DEPARTMENT OF THE AIR FORCE
AIR FORCE RESEARCH LABORATORY
WRIGHT-PATTERSON AIR FORCE BASE OHIO 45433

02 MAY 2008

MEMORANDUM FOR AFRL/RYY

FROM: AFRL/RY

SUBJECT: Declassification of Scientific and Technical Documents Dated 1982

IAW E.O. 12958, as amended, the following technical documents have been reviewed and determined eligible for declassification. I approve the declassification of the following documents to reflect unclassified.

~~(U) EO SAM Simulator. Volume II, dtd Apr 82~~ ✓
(U) EO SAM Simulator. Volume I, dtd Apr 82 ✓
(U) Face Pumped Laser Slab Mounting Development, dtd Feb 82 ✓
(U) Future Directions in Computer Modeling Aircraft for RCS Prediction, dtd Mar 82 ✓
(U) Molecular Flare Feasibility Study, dtd Apr 82 ✓
(U) FLIR Technology Demonstration (FTD), dtd May 82 ✓
(U) Radio Frequency Radar Cueing, dtd Apr 82 ✓
(U) RF Chains Demonstration, dtd May 82 ✓
(U) SAW Receiver Final Report, dtd Oct 82 ✓
(U) Power Sharing: Phase II, dtd Nov 82 ✓
(U) Solid State Aperture Module Development Program, dtd Dec 82 ✓
(U) Passive Optical Expendable Countermeasures, dtd Apr 82 ✓
(U) RF Chain Final Technical Report, dtd Jan 83 ✓
(U) Low Cost Arrays for the Detection of Infrared. Phase II, dtd Jan 83 ✓

DAVID M. JEROME, SES
Director, Sensors

**DEPARTMENT OF THE AIR FORCE**
AIR FORCE RESEARCH LABORATORY
WRIGHT-PATTERSON AIR FORCE BASE OHIO 45433

FROM: Det. 1 AFRL/WSC(STINFO) 28 MAY 08
2261 Monahan Way, B.196, Rm.1
Wright-Patterson AFB, OH 45433

The following technical reports are now unclassified, Statement B, Test and Evaluation , Controlling office: AFRL/RYJW ; EXPORT CONTROL

| | | |
|---|---|---|
| **EO SAM Simulator** | AFWAL TR 82 1002 VOL. I | ADC029419 |
| **EO SAM Simulator** | AFWAL TR 82 1002 VOL. II | ADC029420 |
| **Passive Modulated Expendable Optimization** | AFWAL TR 82 1048 | ADC030479 |

The following technical reports are now unclassified, Statement D, Test and Evaluation, Controlling office: AFRL/RYJT ; EXPORT CONTROL

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| **FLIR Technology Demonstration (FTD)** | AFWAL TR 82 1019 | ADC029216 |
| **Low Cost Arrays for the Detection** | AFWAL TR 82 1165 | ADC033455 |

The following technical reports are now unclassified, Further dissemination only as directed by the Sensors Laboratory (AFRL/RYJW) or higher DoD authority. EXPORT CONTROL

**Passive Optical Expendable Countermeasures** AFWAL TR 82 1157 ADC031190

The following technical reports are now unclassified, Statement C, Critical Technology; Controlling office: AFRL/RYJW ; EXPORT CONTROL

**Face Pumped Laser Slab Mounting** AFWAL TR 82 1006 ADC030426

The following technical reports are now unclassified, Statement E, computer software; Controlling office: AFRL/RYJW ; EXPORT CONTROL

**Molecular Flare Feasibility Study** AFWAL TR 82 1017 ADC951650

The following technical reports are now unclassified, Statement X, all other requests for this document shall be referred to AFRL/RYRE; EXPORT CONTROL

**RF Chains Demonstration** AFWAL TR 82 1052 ADC029911

The following technical reports are now unclassified, Statement A, Controlling office: AFRL/RYRE

| | | |
|---|---|---|
| **RF Chain Final Technical Report** | AFWAL TR 82 1160 | ADC032271 |

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| **Radio Frequency Radar Cueing** | AFWAL TR 82 1022 | .ADC030697 |
| **SAW Receiver Final Report** | AFWAL TR 82 1101 | ADC030747 |
| **Solid State Aperture Module Development** | AFWAL TR 82 1153 | ADC031011 |

The following technical reports are now unclassified, Statement B, computer software; Controlling office: AFRL/RYRT ; EXPORT CONTROL

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| **Power Sharing: Phase II** | AFWAL TR 82 1106 | ADC030865 |

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| **Future Directions in Computer** | AFWAL TR 82 1015 | ADC029416 |